PRACTICAL RAILWAY OPERATING

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PREFACE

THIS book is intended to supplement the discussion contained in, and to supply the illustrations—both verbal and otherwise—which, for reasons explained in the preface, were omitted from, *British Railway Operation*. Whilst, therefore, it may be necessary to introduce particular cases by a general consideration, it is not proposed to encroach upon the ground already covered by the former work, it being assumed that, so far as may be necessary, the reader is familiar with the principles set out therein. For convenience the same general order will be followed.

In a book of this length one cannot hope to consider all the principal operating problems which are likely to arise, or which should be searched for; nor is it suggested that the method used in any particular case is necessarily the best one for that type of problem under all circumstances. What the writer will endeavour to do is to discuss problems that are typical of the different sections of railway operating, using the method which he has found to be most generally useful in each case.

As on the previous occasion, I must acknowledge my indebtedness to a large number of railway colleagues of all ranks and grades who have, from time to time and in many different ways, helped me to the conclusions which follow. I would especially like to acknowledge my indebtedness to my fellow members of a class, organized on tutorial lines, which was conducted jointly by the Hull University College and the Hull (L.N.E.R.) Railway Lecture and Debating

Society, and of which I had the privilege of acting as chairman. This class, consisting of twelve railwaymen of different grades under the leadership of the head of the department of mathematics of the Hull University College, considered the value of the three-aspect signalling from the operating point of view.* This necessitated a preliminary investigation of the principles underlying present-day signalling, and I must gratefully acknowledge the assistance its discussions gave in clarifying and confirming many of the views expressed in the chapter dealing with line capacity.

*Readers who are interested will doubtless be able to obtain copies of the report of this group on application to the University College, Hull

CHAPTER I

INTRODUCTORY

IN *British Railway Operation,* a companion work by the same author, an endeavour was made to define and discuss the general principles underlying railway operation. The object of this book is to examine the more practical aspects of railway operation.

It is often suggested that present-day conditions have raised a new series of problems, but the writer has difficulty in accepting this view. The operating problems of to-day are much the same as those which have had to be faced since the early development of our railway systems. They are difficult ones, because the task is to arrange for the quick conveyance of almost innumerable small units of different sorts, which vary in every possible respect, by means of machinery the very justification for which lies in the fact that it is capable of handling large units economically.

Modern conditions have made the task more difficult in many ways. The units have tended to grow smaller and increase in number. Working costs have increased from causes over which the operating officer has had little or no control. Moreover, a competing form of transport has been developed with special advantage in many directions. This has made the old problem of carrying traffic quickly, and, at the same time, keeping the cost low, a more urgent one. The task is rendered more complicated by

the fact that his colleagues in the engineering and other sections of the railway industry have invented and developed an increasing variety of locomotives, and improved signalling and other apparatus. These, it is true, have been devised to assist; and there can be no doubt but that in most cases they have done so. It is equally true that the variety which is the natural result of the development of such apparatus also tends to make the task more complicated.

The scope for the solution of the problems is narrowed by the financial position in which all British railway companies find themselves to-day. This feature must not be regarded as an unmixed evil. The economic urge to greater operating efficiency without additional capital expenditure has already proved a valuable tonic, and experience is proving that adjustments made with the primary object of increasing efficiency in the sense of improved service are more often than not also efficient from the point of view of operating cost. The reverse is equally true.

It should not be necessary to emphasize that the general aim in railway working, as in that of all other forms of transport, is to keep traffic moving; but it is not so generally recognized that economical working, particularly in the case of railways, depends very largely upon the extent to which it is possible to do this. So long as traffic can be, and is—within the limits of what is reasonable for a concern fitted for operations on a large scale—kept moving, the working costs per unit of distance carried are comparatively light. They increase very rapidly, however, when movement ceases, and although this may sometimes be necessary or desirable, in order to make a more than equivalent corresponding gain later, the general statement as to the effect this has on working costs still remains true. It is commonly accepted as a principle of rate making that terminal costs are heavy. It is not so well appreciated that, in a transport sense, every place where there is a break of journey is, in effect, a terminal. It is not only

the waste owing to locomotives and other rolling stock ceasing to be of effective use. The fact that it is necessary to provide additional accommodation of an expensive character on which the vehicles and traffic may rest pending a forward movement, and the cost of putting it there and getting it out again add considerably to the initial waste. In general, then, the aim of railway operation may be said to be to find means of keeping traffic moving between its points of origin and destination.

The different aspects of railway operation are so interwoven that it is by no means easy to dissect them for convenience of discussion or illustration. Moreover, without quoting actual cases—which for many reasons is undesirable—it is not easy to define the question or group of questions under consideration. The problems to be solved are not always self-evident. In many cases, indeed, the difficulty lies rather in the discovery of the problem, the solution following almost automatically. It is not only, or even chiefly, a question of putting right what is wrong, or even of adjusting matters to meet varying flows of traffic or other changed traffic conditions. Both these are, of course, important; but as a rule the need for them will only occur intermittently. At the best, the solution of the problems which are self-evident, or which appear as a result of routine supervision of the working, can do little more than preserve the standard of efficiency already reached. If a real advance is to be made, something more is necessary.

There is a type of railwayman—and the type is by no means confined to any particular grade—who appears to have an instinct for seeing in a given set of circumstances the possibilities for increased efficiency. Without any carefully prepared data, a set of circumstances, which, apart from some apparently unimportant detail, he may have had in his mind on many previous occasions, seems to suggest the possibility of improvement, even though the existing method may hitherto have been accepted by all concerned, himself included, as quite satisfactory. How

far this is the result of some inborn quality, and how far it may be due to or developed by the study of and concentration on railway problems in general, is a subject outside the scope of these articles. The value of this source of progressive ideas is so considerable that no opportunity of encouraging and developing the possessor of such a faculty should be missed. Entire reliance upon the happy coincidence which brings the right type of mind into touch with the right set of circumstances at the proper moment, is, however, hardly sufficient to sustain the necessary degree of efficiency in an industry at the stage of development that our British railway system has reached. It is, therefore, most important of all to review systematically the different aspects of railway operation to discover whether fresh and more efficient methods of working can be substituted for those hitherto accepted as satisfactory, and it would appear to be clear that it is only by concurrent investigation into the possibilities to which attention is attracted by the four different methods mentioned, that the general standard of railway operation can be raised.

No one method of approach appears to lend itself to the presentation and solution of the different problems. In most, if not, indeed, all of them, the selection of the correct method of setting out the case is of paramount importance: if the facts can clearly be represented so that their proper relation to each other may be appreciated, even though their respective values cannot be reduced to a common denominator, the indication of the correct course of action is often apparent. For some, the graphical method seems almost ideal; for others, a comparison of the theoretical "possible" with the "actual." In a few cases a purely statistical analysis is sufficient, though, as a rule, owing to the difficulty of bringing the whole of the different factors into whatever figure may be chosen as unit, the statistics available do little more than indicate the places where further investigation might bear fruit, and necessitate some other method for the investigation proper. On

the other hand, some of the problems do not lend themselves to any other treatment than the consideration of the facts of the particular case, the difficulty being that the factors are so liable to vary in value from day to day, or even from hour to hour, that the value of any suggested alteration can only be estimated in the light of experience and only be judged by the result.

CHAPTER II

THE PROBLEM OF LINE OCCUPATION

LINE capacity is a term by which we endeavour to express the amount of traffic, represented by the number of trains, which can be passed over a line in a given period, without breach of the regulations in regard to the signalling of trains which have been considered necessary in the interests of safety. It really expresses a very indefinite idea of line capacity in terms of traffic, because of the varying value of the train unit and the other varying factors which are liable to affect it. For example, a light engine is, equally with a heavily-laden goods train or express passenger train, treated as a unit for this purpose. Moreover, it can be increased or reduced, either by varying the speeds of the different trains or even by varying the order of the trains of different speeds, or by improving the signalling equipment.

It is not possible, therefore, except in relation to a given set of traffic conditions, to work out a standard line capacity for any given line.

The term "line occupation" is generally used to denote the degree to which the line is actually used. Like line capacity, however, it is a somewhat elastic term, and a given set of circumstances is necessary before it can be expressed very definitely.

Over a reasonably long period of time it is clear that total line occupation cannot exceed line capacity, nor, indeed, can it do so for even a short period. What does

happen not infrequently, however, is that a series of trains in excess of the capacity may be directed to a line, thus giving the impression of a temporary excess of capacity. The rules of block signalling have the effect of holding up such of the trains as represent the excess, and, by spreading them over a longer period of time, reduce the flow to the rate the capacity allows. When this state of things has reached a more or less chronic state, it is usually referred to as congestion, and steps are taken to increase the line capacity. In the meantime, waste of engine power, train crew time and rolling stock takes place, and the efficiency of the service is reduced. If, on the other hand, line occupation is much below line capacity, waste of another type takes place. The cost of unnecessary signalmen, signalling equipment, and even of permanent way may arise, and continue until such time as the capacity is reduced to occupation requirements by dispensing either temporarily or permanently with the use of some of the equipment. In passing, reference might be made to the waste which unequal sections cause under either set of circumstances, and, though space does not permit of much further reference to this aspect of the question, which was dealt with fairly fully in *British Railway Operation,* certain features which are discussed later will bear incidentally upon it.

Before we consider a method whereby a reasonably correct general impression of the line occupation over a considerable area can be obtained, it is interesting to notice that a general figure of line occupation on a continuously open line, with passenger and freight trains in approximately equal proportions, is about one hundred trains per twenty-four hours. As has already been mentioned, this will be liable to vary according to the different rates of speed of the trains and the sequence the trains of the different speeds follow, which points will be developed later; but, under British conditions, one hundred trains per twenty-four hours is by no means a low figure. Working out, as it does, at approximately four trains per hour, and comparing it with the maximum of about forty-four trains

per hour which is the line occupation of some of the busier sections of the London Underground Railways, the question would appear to be one that is well worth consideration in further detail.

Neither line capacity nor line occupation is sufficiently stable to enable a comparison between the two to be made in any sort of permanent form, whilst a concurrent detailed examination of the whole of a large area in relation to any particular set of services is liable to take too much time, in addition to which the resultant data would be somewhat unwieldy. In the first place, therefore, a general impression of the line occupation is valuable as an indication of the sections over which a more detailed examination is likely to yield good results. A convenient way of obtaining this is to take a periodical census of trains passing over each branch and to produce the result in some handy form which will lend itself to the ready appreciation of the position. Those who have not previously adopted an arrangement of this sort may believe it should hardly be necessary; but many practical railwaymen have been surprised to find how largely it corrects the general impressions they have formed from daily acquaintance with traffic conditions in the absence of such a record.

The representation of the facts, as well as their consideration, would be much simpler if the variation in the number of tracks only occurred at points where routes diverge or converge. In practice, however, this is not the case, and, as the question of line occupation is obviously affected by the number of tracks in the same direction, the figures for each individual track must be clear whatever form may be adopted. The choice appears to lie between a tabular form or what can be described as a geographical diagram, i.e., a geographical representation of the line adjusted sufficiently to enable the figures to be shown conveniently. The writer prefers the tabular form, though the diagram is probably superior in all cases where the user is not perfectly familiar with the lay-out. An examination of Statement A, which conveys very little of the real

position until the geographical position is appreciated by examination of Diagram 1, the alternate form of record, will confirm this. The statement is almost self-explanatory, and, with a knowledge of the geographical arrangements of the area, is sufficient to convey a clear impression of the general position and indicate the most fruitful ground for further detailed inquiry. The geographical diagram, with the notes accompanying it, is equally self-explanatory. The method of indicating the occupation of the separate tracks, where these are doubled, will be noticed; whilst, if additional records are required on the same diagram, these may be added in different coloured inks.

Consideration of the statement or diagram draws attention to the fact that, in relation to the hours open, the most heavily occupied line is *PN*, and, since the trains over this section of line are known to continue to *M* and *G* respectively, those sections of line are the ones which we will use for the further detailed analysis. Before we do this, however, it is desirable we should consider in more detail certain features which affect line capacity.

In giving first place to the consideration of the effect of the speeds of trains on line capacity, we are influenced by the fact that, within certain limits, they can be adjusted at less expense and at shorter notice than alterations to the signalling arrangements can be made, or additional line accommodation provided. It is legitimate to suggest that, to some extent, the advantage derived from any increased speeds will be neutralized, because the increased speed will naturally demand a reduced load, and, in turn, an increase in the number of trains to carry a given traffic. In the long-run, this tendency would be corrected by the construction of improved types of engines, but the immediate result would undoubtedly be to increase the number of trains. An examination of the effect of such increase in speeds, however, indicates that this will be nothing like sufficient to neutralize the very considerable advantage gained. The advantages resulting from the higher speed alone will be more than sufficient to counteract the loss in load, leaving

STATEMENT OF LINE OCCUPATION: TUESDAY 25/6/29.

Up Line

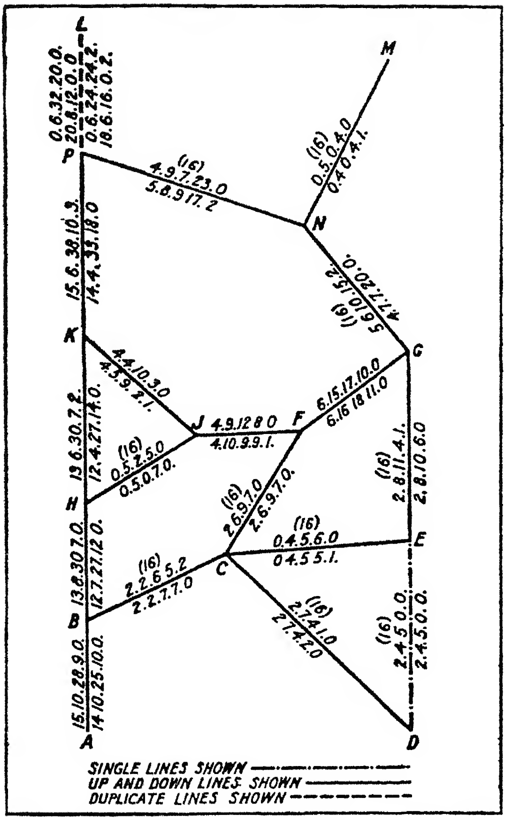
Between	Hours Line Open	E.P.	O.P.	E.F.	O.F	L E. or E &V	Total
		Description of Train					
A and B ..	24	14	10	25	10	0	59
B ,, H ...	24	12	7	27	12	0	58
H ,, K ..	24	12	4	27	14	0	57
K ,, P ..	24	14	4	33	18	0	69
P ,, L ...	24	20	8	12	0	0	40*
		0	6	32	20	0	58†
B ,, C .	16	2	2	7	7	0	18
C ,, F ..	16	2	6	9	7	0	24
C ,, E ...	16	0	4	5	5	1	16
C ,, D ...	16	2	7	4	2	0	15
K ,, J ...	24	4	4	10	3	0	21
H ,, J ...	16	0	5	0	7	0	12
J ,, F ...	24	4	10	9	9	1	33
F ,, G ..	24	6	16	18	11	0	51
P ,, N ...	16	4	9	7	23	0	43
N ,, M ...	16	0	4	0	4	0	8
N ,, G ..	16	4	7	7	20	0	38
G ,, E ..	16	2	8	10	6	0	26
'E, ,, D ...	16	2	4	5	0	0	11‡

Down Line

Between	Hours Line Open	E P.	O P	E F.	O F.	L.E. or E &V.	Total
		Description of Train					
A and B .	24	15	10	28	9	0	62
B ,, H ...	24	13	8	30	7	0	58
H ,, K ...	24	13	6	30	7	2	58
K ,, P ...	24	15	6	38	10	3	72
P ,, L ...	24	18	6	16	0	2	42*
		0	6	24	24	2	56†
B ,, C ...	16	2	2	6	5	2	17
C ,, F ...	16	2	6	9	7	0	24
C ,, E ...	16	0	4	5	6	0	15
C ,, D ...	16	2	7	4	1	0	14
K ,, J ...	24	4	5	9	2	1	21
H ,, J ..	16	0	5	2	5	0	12
J ,, F ...	24	4	9	12	8	0	33
F ,, G .	24	6	15	17	10	0	48
P ,, N .	16	5	8	9	17	2	41
N ,, M ...	16	0	4	0	4	1	9
N ,, G ...	16	5	6	10	15	2	38
G ,, E ..	16	2	8	11	4	1	26
E ,, D ...	16	2	4	5	0	0	11‡

* Main line. † Independent. ‡ Single line.

Statement A



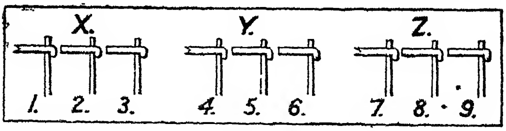
The five figures indicate the numbers of the different classes of trains in the following order: Express passenger, slow passenger, express freight, slow freight, light engines or engines and vans. Where there are duplicate lines, the figures for the independent line are shown above those for the main line. Where the line is open for less than 24 hours the number of hours open is shown above the train figures, thus (16).

Diagram 1.

the gain from any reduction in speed variation to be added.

It is not necessary to enlarge on the fact that an all-round increase in the speed of all the trains will help in the direction indicated. We may confine our inquiry to the possibility of adjustments in the speeds of the trains which, on examination, contribute most of our difficulties—generally speaking, the trains whose speeds are abnormal—and of improved grouping of the trains of similar speeds. For either purpose it is necessary that we shall understand what the effect is of succeeding trains running at differing speeds. It is frequently stated that the principle underlying the standard block regulations, which are in general use on British lines, is that no more than one train may be allowed to be in a block section at the same time. In practice, the effect of the application of the present standard regulations is to restrict one train not to one block section only, but to nearly two block sections if it is assumed that trains are to continue to run at normal speeds. From all points of view we can say that it is desirable that trains shall do so. Line capacity is reduced, not increased, if the headway is such that a train is checked at the distant signal; because the time lost in regaining normal speed more than counterbalances the time gained by the additional forward distance it is allowed to travel, after the check, at reduced speed. Moreover, the statistics which were prepared for use in connection with the report of the committee of the Institution of Railway Signal Engineers on three-aspect signalling demonstrate the generally accepted fact that frequent applications of brakes are wasteful.

The diagram below, giving the standard signalling for three successive block telegraph sections, can be used to give a simple demonstration of the length of headway necessary to keep trains moving at normal speeds. *X*, *Y* and *Z* are three signal boxes, with normal signalling:



If we assume a train has passed through the section controlled by *X*, it will have passed signal 3 into the section controlled by *Y*, and, on the theory that one train is allowed in a section at once, a following train might be passing signal 1. The signalman at *X*, however, may not lower his signals 1 and 2 until *Y* has sent the "train out of section" signal for the preceding train and accepted the second one, which he is not allowed to do until the first train has passed signal 5 and is proceeding towards signal 6. A second train can, therefore, only run at normal speed up to signal 1, when the driver must begin to apply the brakes so as to be in a position to stop at signal 2. It is not until the first train has passed signal 5, and the necessary bell signals have been exchanged, that signals 1, 2 and 3 can be lowered to allow a following train to run through the section controlled by *X* at normal speed. The effect of the rules, therefore, is to extend the principle of "one train one section" to the extent described above, i.e., one train, running at normal speed, per section plus the distance up to the home signal of the second section.

There are many modifications of the standard regulations and methods of signalling which appear to indicate that this may be regarded as an unnecessarily high standard of safety. We are not, however, concerned with that here, but are merely drawing attention to the effect of the regulations on the subject we are considering.

It will be clear that if we take an ideal case in which all the trains run at the same speed, and the time distance between succeeding signals in the positions comparable with those of signals 1 and 5 on our diagram are equal, the maximum line capacity can be obtained by starting succeeding trains at intervals equal to the time taken to run through this headway distance, as we will describe it in future. Thus, if the headway distance is fifteen minutes, trains can follow each other at intervals of fifteen minutes, so that the line capacity will be four trains per hour, whilst any variation of speed will proportionately affect the

capacity. In practice, the speeds of trains are not equal, and the unevenness is accentuated when we regard, as we must for our present purpose, speed from the point of view of the time taken to traverse a headway distance, even including service and other stops, during which the running line continues to be occupied. We can best consider the effect of this by comparing the progress made by trains of different speeds in graph form, and, incidentally, begin to appreciate the effect the variations in speeds on British main lines have in reducing line capacity.

In Diagram 2 the vertical lines represent time intervals, as shown, and the thick horizontal lines the boundaries of the successive headway distances. The sloping lines represent the trains, which have been kept at the intervals necessary to enable them to run without check. For convenience, it has been assumed that no time is spent in exchanging the necessary block signals or pulling off the fixed signals after this has been done. The only effect of a small fixed allowance for these operations would be to extend slightly the total time necessary to pass the trains shown over the line. Trains at *X* speed may be dispatched at intervals of five minutes, giving an occupation of twelve trains per hour. *Y* speed trains need twice this headway distance, and thus give a line capacity of six trains per hour.

The introduction of a train at the higher speed between two trains at the lower speed reduces the possible occupation to less than four trains per hour, and that of one lower speed train between two of higher speed has a precisely similar effect, though the direct effect is felt at different ends of the journey. In other words, the introduction of one exceptional train, whether faster or slower, immediately causes a very marked reduction in the line capacity. In this particular case the omission of the exceptional trains would have given an increased line capacity more than equivalent to increasing a single track to two tracks.

The diagram also attracts attention to the advantages to be obtained from the grouping of trains of similar speeds,

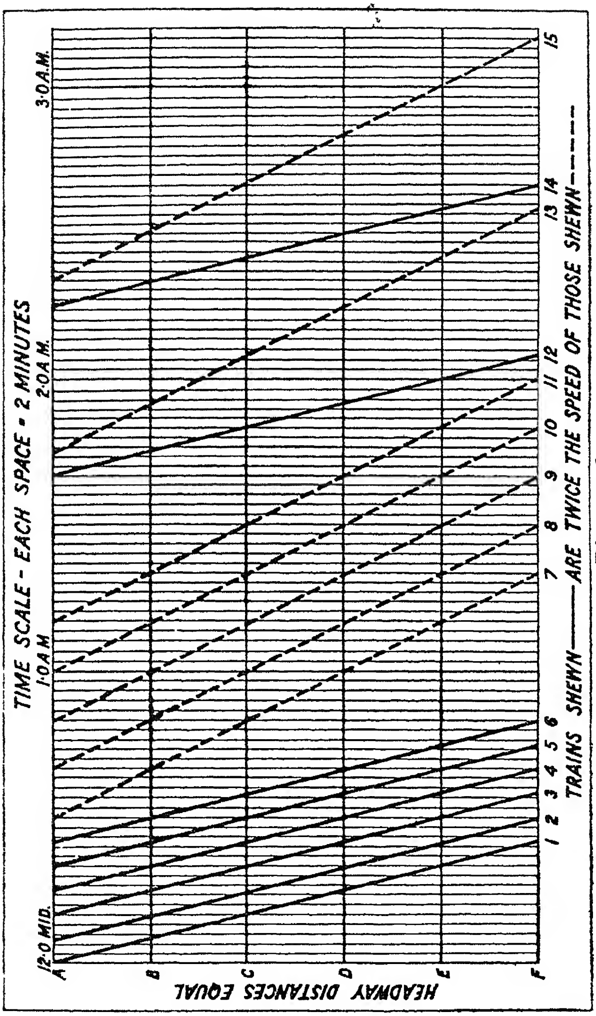

TIME SCALE - EACH SPACE = 2 MINUTES
12·0 MID.
1·0 A.M.
2·0 A.M.
3·0 A.M.
A
B
C
D
E
F
HEADWAY DISTANCES EQUAL
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
TRAINS SHEWN —— ARE TWICE THE SPEED OF THOSE SHEWN - - - -

Diagram 2.

and simple as it is, it is worth very careful consideration as a preliminary to the examination of a practical case.

It must also be noticed that the extent of the effect of variation of speeds upon the reduction in the line capacity increases with the length of the line between junctions. For example, if the terminus had been at *E* instead of *F*, train 12 could have left five minutes earlier, i.e., the time represented by the distance from *E* to *F*, with a similar reacting gain on the succeeding trains, as also could train 14. Similarly, as the distance of the line *A*—*F* extends, the loss would increase.

Passing now to the effect of unequal headway distances it will be clear without demonstration that for trains running at the same speed, the longest headway distance between any two junctions will govern the rate at which one train may succeed another, and that if, owing to this important fact being overlooked, or for any other reason, trains are dispatched at shorter intervals than this longest headway distance allows, a definite loss of line capacity is suffered owing to the trains which are stopped at the point where the effect of the long headway distance begins to apply occupying more than the normal running time through the next one, while regaining speed. This is, in effect, equivalent to an increase in the length of the ruling headway distance.

What is not quite so obvious is the effect of unequal headway distances when successive trains vary in speed. It seems quite clear that if a slow train is following a faster one which is capable of getting far enough ahead before arriving at the ruling headway distance to clear it without checking the slower one, the slower one might be dispatched at the interval settled by a preceding shorter headway distance, the actual distance varying according to the speeds of the trains, and the relation between the varying headway distances. In other words, there will be cases where the effect of the unequal speed is sufficient to counteract the effect of the unequal headway distance.

In other cases, the effect is not quite so obvious, and an

examination of Diagram 3 will assist in a consideration of the position. In general, Diagram 3 is on similar lines to Diagram 2: the perpendicular lines representing time intervals, the horizontal lines the boundaries between the successive headway distances, and the sloping lines the trains passing over them. The actual mileage represented

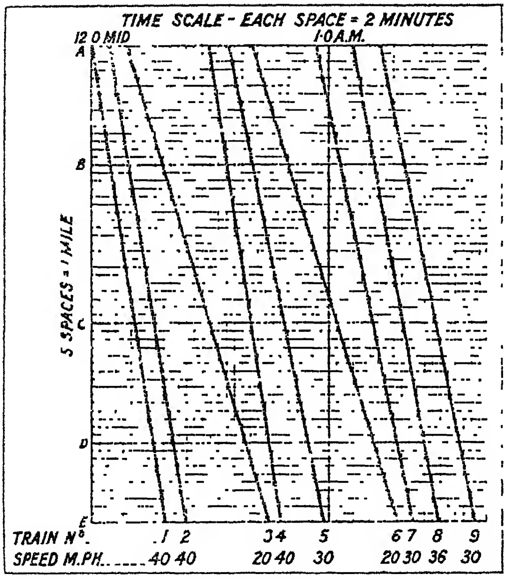


Diagram 3.

by the different headway distances is not important, since it is their relation to each other which matters most; but it may simplify a consideration of the diagram if we describe them as being 3 miles, 4 miles, 3 miles, and 2 miles long respectively. The vertical scale is two minutes to one square. Trains of four different speeds have been introduced, running at average speeds of 40, 36, 30, and 20 miles per hour respectively. The trains are numbered for easy reference, and their speeds are shown at the foot of

the diagram. It will be noticed that trains numbered 1 and 2, running at similar speeds, must maintain an interval throughout equivalent to that of the longest headway distance. If train No. 2 had left "A" immediately train No. 1 had cleared "B" then it would have to wait on arrival at "B" until train No. 1 had cleared "C." It would, therefore, have had an unnecessary stop, and the time necessary to get into speed again after train No. 1 had cleared "C" would have resulted in its taking a longer time to clear "BC," which would have reacted on the following trains.

Passing now to trains at different speeds, and dealing first with the case of a slow train following a faster one, we notice that train No. 3 can leave "A" as soon as train No. 2 has cleared "B," because the latter can clear "C" before train No. 3 reaches "B." If, however, trains Nos. 8 and 9 are taken, though No. 9 is a slower train than No. 8, the effect of the unequal headway distance is added to that of the unequal speed, because the difference in speeds is not sufficient to enable train No. 8 to clear "C" before train No. 9 reaches "B," if the latter leaves "A" as the former clears "B." The effect on a following train of higher speed also varies according to the relation between the speeds and the lengths of the headway distances. In this case, however, it is the headway distances at the end of the journey, instead of the beginning, that become important, as we shall see as we proceed to examine typical cases. For example, the interval at which train No. 4, being faster than train No. 3, can follow it, will, according to the principle established when considering Diagram 2, be governed by the time it can leave "D" on train No. 3 reaching "E," unless this is affected by the irregular headway distances. From an examination of the diagram, it will be seen that it is not so affected in this case. If, however, we compare trains Nos. 7 and 8—another case in which a faster train is following a slower one—we notice that the longer headway distance has added its effect to that of the irregular speeds. The difference between the

cases is the difference in ratios between the speeds of the successive trains, these being as 1 is to 2 and as 5 is to 6 respectively. The former pair necessitate a bigger interval in starting time, and, consequently, reduce the chance of overtaking the preceding train before the latter has cleared the longest headway distance.

As we have already seen, this interval varies, even when the headway distances are equal, according to the length of the line and the number of headway distances into which it is divided, while the effect of the headway distances is also liable to vary according to the position of the longest headway distance in relation to the shorter ones.

We may, therefore, sum up by saying that, considered separately, unequal speeds and unequal headway distances have a considerable adverse effect on line capacity, and that, when combined, the adverse effect tends to become cumulative.

It is not proposed here to deal with the different methods of adjusting or increasing the number of headway distances, should this appear to be desirable. They may be said to vary from the simple adjustment of signal locations to the installation of automatic or semi-automatic signalling. The points the writer is anxious to emphasize here are the importance of knowing, in relation to a particular section of line, what the occupation is, and how it is affected by the factors already referred to; and also that it is not sufficient to consider such questions only in relation to a line where difficulty is being experienced. An examination should be made periodically of all lines, with a view to discovering the possibilities in the direction of effecting improvement or economies by (a) rearrangement of the train working (b) the closing or reopening of signal-boxes either for portions or the whole of the working day; (c) reducing, improving or increasing signalling equipment; (d) abolishing existing facilities that may be unnecessary; or conversely, providing additional running accommodation where difficulty cannot be overcome by other means.

We have now reached the stage where we can, with

advantage, consider in detail the working on certain branches selected from Diagram 1 or Table A, pages 10 and 11.

As previously stated, an examination of the table or diagram indicates line "PN-NG" and "NM," as promising ground for more detailed examination. The line "PG," with its total of forty-three trains in one direction and forty-one in the other during the sixteen hours the line is open daily, is one of the most heavily occupied lines in the area; whilst the line "NM," which, incidentally, is that most lightly occupied, works in such close conjunction with it that it is convenient to consider them together. Before arranging for the preparation of a detailed diagram, some consideration must be given to the question of whether it should represent the booked working—what ought to have happened—or the actual working. The booked working, at its best, represents what has been aimed at, rather than what in practice happens, on a line on which a number of freight trains run, since the running of this class of train is liable to be affected by all sorts of considerations which at present appear to be only partially controllable.

A diagram representing the actual working is, therefore, preferred as representing a truer picture of what is taking place. Incidentally it may call attention to a few cases of bad booking. It is, of course, important to select a day when the working may be regarded as fairly typical, and in any case conclusions arrived at as a result of the examination of one day's working in diagrammatic form will require to be confirmed by reference both to the booked working and the actual working on other days before any alterations are made. The type of diagram which the writer has found convenient is on similar lines to those we have already considered and to the train-timing diagrams which will be familiar to many readers, having been used for some years for that purpose. The principal difference is that, in plotting the trains on to the diagram, the time is taken at each of the boundaries of the headway

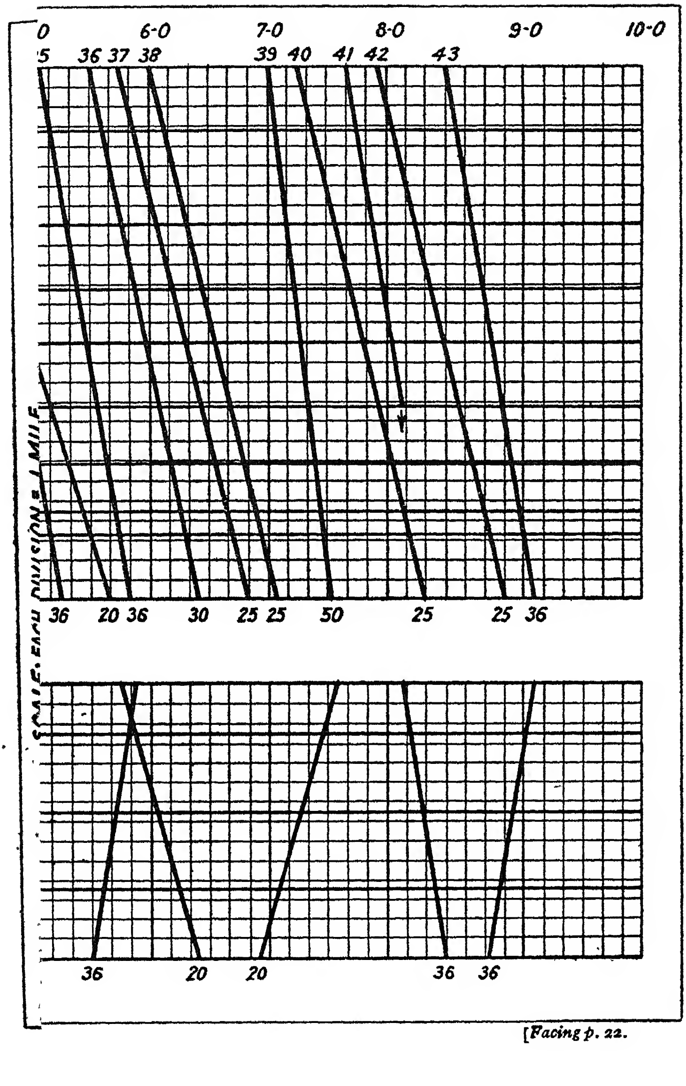
distances as an alternative to occasional points represented by the positions of the more important signal-boxes, or the advance signals which form the boundaries of the block sections. The use of the signal-box for the purpose is very liable to be misleading, unless the signals of the different types are very evenly spaced throughout the branch, though this, in turn, is better than the use of a throughout timing which entirely ignores intermediate points.

In order to make Diagram 4 suitable for reproduction without losing its legibility, certain deviations from normal practice have been found desirable. For example, it is convenient to show the different types of trains in different colours, and describe them so that they can be recognized by those familiar with the time-table. It is also convenient to show the horizontal part of the train line in red if it represents delay as compared with legitimate work at a station. Substitutes for colour representation have been arranged as follows: The trains have been numbered consecutively at the top of the diagram as a means of identification; the speeds of the trains are given at the foot of the diagram; whilst delays are indicated by dashes in place of the unbroken horizontal lines representing legitimate work. The scales used for Diagram 4, even before the further reduction necessary for reproduction purposes, were too small for a busy line. In practice, the writer would recommend, for general purposes, a time-scale of approximately 1-16 inch to a minute and a distance scale of approximately half an inch to a mile. These can, however, be varied with advantage according to the density of the traffic, the number of sections and the types of trains. Actually the best arrangement for any individual case can only be determined by experiment. Normally, on busy lines it is better to use a separate diagram for up and down trains. Where the line occupation is sufficiently light for the same diagram to be used in both directions, some slight advantage is gained at the loss of a little clearness. Wherever a branch line takes off, it should, where possible, be included in the diagram for the side on which the

divergence takes place and the trains in both directions shown, so that the effect of the junction working is apparent. Thus, in Diagram 4 the effect of all trains between "N" and "M" on the line at "N" is apparent.

Let us now try to read the messages conveyed by the diagram. It is probable that the first feature to attract attention will be the apparent waste of time on a line where the occupation is so near its maximum, at the end of the working day. If the diagram for the reverse direction were available, a similar apparent waste would appear at the beginning of the day. This is due to there being no engine shed at "G," with the result that, in order to close the line within the sixteen hours represented by the two shifts of signalmen, the last engine must leave "P" in sufficient time to enable it to perform a trip to "G" and return to its shed for the night. With a similar waste of approximately one and a half hours at the other end of the day, we see that the line, although open in theory for sixteen hours, is, in effect, only open for thirteen hours. Had it been possible to stable engines at "G," engines could have started and finished at both ends of the line simultaneously, enabling the train working to have been spread over the full sixteen hours to better advantage, or, alternatively, the line capacity to be increased by approximately 10 per cent.

If the diagram had been in colour, no keen railwayman could for long have resisted the temptation to inquire into the red lines (indicated here by dotted horizontal lines) which indicate delay. Let us now consider some of them. Why was train No. 17 delayed at "B" and at other points on its journey? The great advantage of the diagram form is that it not only raises questions of this type, but enables them to be answered. In so far as they are due to line occupation, as most of them are, there is no need to refer to other documents or calculate margins. They are apparent. Train No. 17 could not proceed past "B" because train No. 16 had not cleared the next headway distance. The question then arises: why was an attempt made to run it at this time? If both trains were running


6-0
7-0
8-0
9-0
10-0
36 37 38
39 40
41 42
43
SCALE: EACH DIVISION = 1 MILE
36
20 36
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36

[*Facing p. 22.*

than one would normally find in practice on a line where the occupation is so near the capacity as this one is; but, in any case, it is desirable that longer recovery intervals should be provided between the trains wherever possible.

A closer examination of the diagram draws attention to the possibility of increasing the capacity of this line by a better grouping of trains of similar speeds. For example, if trains Nos. 22 to 28 had been rearranged to run in the following order, 22, 24, 26, 25, 23, 27, 28, four additional trains could have been run in a similar time. In other words, line capacity would have been increased by approximately 50 per cent. If the additional trains were not required, this time could be utilized to increase the intervals between existing trains which would have reduced, at any rate, some of the reacting delay which has already been discussed. An even greater advantage could be derived by raising the speeds of the slowest trains from twenty to twenty-five miles per hour. Any reader who is sufficiently interested can easily work out, on a similar diagram, what this would be. The benefit from a combination of the two methods would very nearly be equivalent to providing an additional running line. In this connection, we must remember that the present construction of British freight rolling stock is such that the maximum speed at which it is regarded as capable of running is between thirty-five and forty miles per hour for modern goods wagons, and from twenty to thirty miles per hour for mineral wagons.

Let us now examine—and again lack of space prevents our doing this on anything but broad lines—the headway distances, and their effect upon the working. Dealing first with the line "PNG," it will be noticed that these distances vary from 1¼ miles to 4¾ miles. In a foreshortened diagram, as this one must necessarily be for the sake of reproduction, the differences may appear to be exaggerated. They are not, however, greater than is frequently found in practice. Distance "HJ" is so much shorter than the others that an examination of the train running will

show that it is of no value from the point of view of line capacity. The signal-box, the signals of which form the boundary of the headway distance, may be necessary to control some connection worked from it. We have the choice of two alternatives. We might close the box entirely as a block post and work the connections, when necessary, from a ground frame, adjusting the signals relating to the boxes on either side in such a way that the headway distances are brought nearer to a common length throughout. It will be seen that practically the whole of its distance could, with advantage, be amalgamated with that of headway distance "GH." On the other hand, it may be that the anticipated demand upon the line is such that it would be desirable to leave this distance at its present length, and, by approximately dividing the remaining headway distances and adjusting the signalling so as to make them substantially of the same length, obtain a considerable increase in line capacity. Whether this is worth the expense, will depend upon whether we may wish to pass a greater number of trains over the line, together with a reasonable margin for recovery from emergency delays, than the cheaper methods of increasing line capacity, discussed earlier, will provide for.

Headway distance "BC" is abnormally long. Are our requirements such as to make it worth while to halve it by the introduction of additional signalling appliances? To do so would reduce the margin between trains of equal speeds by approximately one-third, and by an amount similar to the reduction in time taken by the faster train to pass over it in the case of a slower train following a faster one. It would not help much in the case of a faster train following a considerably slower one, as will be apparent from an examination of trains Nos. 2 and 3. A decision on the question will naturally depend, therefore, upon the requirements of the line, and the actual advantage to be derived from it can be worked out in any given case with the use of a diagram. If, however, it is not desirable to shorten it, it is evident there is a strong case

for revising the arrangement of sections throughout the line with a view to reducing their number. Given headway distances of length equal to the one under consideration six would serve for the whole line, in lieu of the nine at present in use.

Turning now to the line "NM," it will at once be noticed that, except on one occasion, all trains leaving "M" have reached "N" before the following train is required to leave, and that the same has applied, without exception, in the reverse direction. It is apparent from this that the intermediate sections are quite unnecessary, and that the up and down lines respectively could each be worked—with a few minutes' adjustment to one train only—under the regulations for working a line by one engine in steam, intermediate signalling thus being dispensed with. Alternatively, with a very slight adjustment to two or three trains, the line could be worked successfully as a single one with, say, one passing place about midway between "N" and "M."

Having dealt in some detail with the abnormal headway distances at each end of the scale, as the more outstanding cases for alteration, we must content ourselves by simply drawing attention to the general scope for adjusting the variations between the other headway distances by adjusting the location of the signals, as opportunity, probably in the shape of the need for renewals, offers.

When, and not until all these comparatively cheap methods have failed to cater for the required number of trains, resort must be made to the more expensive remedy of constructing an additional line for the whole or part of the route. The value of a partial doubling, and the points between which this can be done to the greatest advantage, must depend upon the circumstances of the particular case, though, in many cases, it will be exceedingly difficult, if not impossible, to forecast for many years ahead the general order in which trains of different speeds will require to run. It will be apparent from what has been said that a throughout doubling of the line will far more than double

the route capacity if trains of similar speeds can be allocated to the respective tracks. The value of this diagrammatic method for indicating the need for expenditure on such additional accommodation, and demonstrating that the limit of the possibilities in the way of conducting the traffic over the line without it has been reached, will readily be apppreciated.

In concluding this section, attention must be directed to the fact that the consideration of the working in relation to one line only does not emphasize sufficiently the importance of this aspect of the subject. British lines are not as a rule self-contained lines, but a series of branches over which trains must pass in succession. For a thorough examination of the position, therefore, it is necessary also to consider the working of the different branches at the points where they converge in order to bring out the possibilities of removing the difficulties at the junctions, where, indeed, they are most liable to occur.

CHAPTER III

TERMINALS—PASSENGER STATIONS

QUESTIONS relating to the provision of accommodation at, and the working of, the different forms of termini, are very closely related to the question of line capacity.

Considered in relation to a simple case of a line between two points, the maximum capacity of the whole of the line would as a rule be fixed by the capacity of the termini, since the minimum necessary time at a terminal is, as a rule, considerably greater than the time taken to pass through the minimum headway distance. This state of affairs already exists on the London Underground Railways, the limit to the line capacity being settled by the time the trains spend at stations. Under such circumstances it would be desirable to arrange the signalling equipment in such a way that it would bear a definite relation to the capacity of the termini, since any expenditure on more intensive signalling equipment would be wasteful. On normal British lines, however, the line occupation is affected, not only by the output of the termini of that particular line, but by those of the termini of a large number of other lines leading to or from it. Even on normal lines, however, the point is an important one as emphasizing the need for careful consideration being given to terminal problems. Terminal accommodation, moreover, is liable to be rendered ineffective by circumstances that cannot apply on running lines, namely, the use for storage purposes of accommodation provided as transit

accommodation. Railway vehicles must necessarily remain stationary at terminals for a certain amount of time. Most terminal difficulties are caused by their being allowed to remain longer than is really necessary, and the wasteful results of this are very far-reaching.

Let us deal first with one or two questions affecting passenger stations. The demand for increased passenger station accommodation is by no means an uncommon one, though the number of trains which arrive and depart from our larger stations expressed in terms of arrivals or departures per platform hour during the period between, say, 7 a.m. and 10 p.m. is frequently much lower than one would expect in the absence of such figures. For example, the average for three large stations taken at random works out at under two trains per platform hour, whilst the peak hour for the stations concerned gives a figure of less than three trains per platform hour. There is such a wide difference in the demands made upon the station accommodation as between one type of train and another that such figures must only be regarded as a very general indication. For example, one train may arrive and depart in three minutes, whilst another may have to exchange portions with one or more trains, and have other additional duties, which cannot be performed in less than, say, fifteen minutes, and is therefore, for some purposes, equivalent to five trains in the former class. Moreover, it must be remembered that the passenger service is much less capable of adjustment to suit the available accommodation than the freight service, the peak demands having to be met as these occur, and affording little or no opportunity for the flow of traffic to be spread more evenly over the working hours. At the same time the expenses of providing passenger station accommodation, considered in relation to the figures quoted, is sufficient to indicate the importance of this aspect of railway operation. Then again, as the size of the station increases the general inconvenience to the passenger and the cost of working and staffing the station, tend to increase.

Keeping these features in mind, let us assume that an inquiry is necessary to establish the strength of the case for extended or improved accommodation at Station "K" (Diagram 5), a reasonably large passenger station. Such an inquiry will include the questions of whether the available accommodation is being used to the best advantage, and the best form for the additional accommodation to take, and incidentally may draw attention to certain weaknesses in the engine or rolling stock working as it affects that station. An inquiry on similar lines, therefore, might well be made at a station at which it is not suggested the use of the available accommodation has reached its maximum, as a means of indicating the potential reserve capacity when considering the introduction of additional services, or for the purpose of deciding what improvements, if any, can be made in the working. In choosing the "through" in preference to the "terminal" type of station for our inquiry, we have been influenced by the facts that the latter type has already been dealt with on a number of occasions in relation to actual cases, and that, although the problems the different types raise are similar in principle, the former introduces features which do not arise at the latter.

The accommodation at Station "K," as shown in Diagram 5, consists of two main through platforms between which a line used indiscriminately for standage or shunting purposes is available; two bay platforms, and an engine shed and a limited amount of accommodation for the standage of empty carriages or other vehicles.

The varying demands made upon passenger station accommodation to meet the business and personal habits of the travelling public make it quite impossible to rely upon any such figures as it might be possible to compile of average requirements in different directions over the day as a whole, or over the time the station is open. Moreover, the different sorts of operations by which the different lines are occupied, are such that there would appear to be no better method of presenting the necessary data for con-

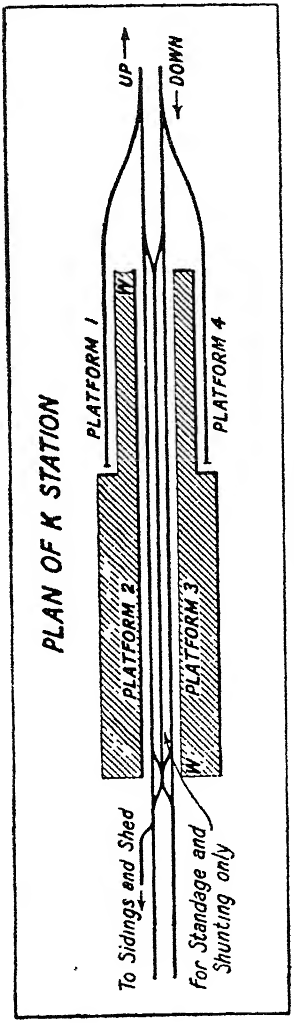
PLAN OF K STATION
UP
DOWN
PLATFORM 1
PLATFORM 2
PLATFORM 3
PLATFORM 4
W
W
To Sidings and Shed
For Standage and Shunting only

Diagram 5.

sideration than in some form of diagram. The form of diagram chosen must be such that it allows of easy representation, not only of the actual occupation by a train or portion of a train, but of the time the line directly concerned in, and the other lines affected by, any movement are rendered unavailable by it, and at the same time enable as many of the features which are liable to affect the occupation of station accommodation to be brought out, so that it may be seen how far these may be adjusted to advantage. A simpler form of diagram than the one illustrated (Diagram 6) would meet the former case, but the advantage to be derived from the inclusion of the additional information is well worth the extra effort necessary to compile, and interpret, the form of diagram shown.

If the case under consideration be such that a representation of the working for an average or maximum day will meet requirements, the diagram can conveniently be ~~be~~ prepared in sections, as indicated. If particulars for a series of days are necessary, it will, as a rule, be more convenient to make the diagram of the necessary length to represent the working for a whole day on one line, and that for the succeeding days in turn below. In this way the working during the same hours of the different days chosen may readily be compared.

Diagram 6 is a portion of a diagram prepared to represent the working at station "K" for a typical day, the portion chosen covering the first six hours during which station "K" is open for passenger train purposes. If the construction of the diagram is compared with the plan of the station given in Diagram 5, its general arrangements will be self-explanatory. It should, however, be mentioned that the principle on which the diagram is constructed is that an indication shall be given of the time during which any of the lines are occupied, regardless of whether occupation is due to a train or portion of a train actually standing on the line concerned, or to its being so affected by some movement that it cannot be used for other

purposes, and that the successive movements of the same train set or engine whilst in the station are indicated by the dotted lines connecting them. The workings have been numbered consecutively, and in order that the diagram may be followed without difficulty, a brief description of the movements of the first twelve trains is now given. Having followed these through on the diagram the reader should have no difficulty in readily reading the remainder of the diagram:—

Train 1: Arrives at platform 1 via platform 2, and departs in Up direction.

Train 2: Arrives at platform 2 and departs in Up direction.

Train 3: Carriages left on middle line overnight joined by engine from shed; drawn to Down main and set back to platform 3, then departs in Down direction.

Train 4: Arrives at platform 2, engine runs round by middle line and draws train to Down main. Sets back to platform 3 and departs in Down direction.

Train 5: Arrives at platform 2, and after unloading is propelled to sidings and shed.

Train 6: Arrives at platform 3, is moved to middle line to allow Down freight train to pass and wait arrival of No 7 via platform 2 to platform 1 before moving to sidings and shed.

Train 7: Arrives at platform 1, via Up main, and departs in Up direction.

Train 8: Arrives at platform 3, is put through middle line to platform 1, the engine running round the set outside the station, and departs in Up direction.

Train 9: Arrives at platform 2, engine runs round by middle line and transfers train to platform 3, then departs in Down direction.

Train 10: Arrives at platform 2 and departs in Up direction.

Train 11: Arrives at platform 4, is propelled out and drawn via middle line to sidings and shed. Returns to platform 3 and departs in Down direction.

Train 12: Arrives at platform 3 and departs in Down direction.

Diagram No. 6 illustrates the working at a station of moderate size. At larger stations, where the interchange between trains and other circumstances tend to complicate the working, advantage may be taken of the use of different colours to prevent the complications of the working increasing the difficulty of interpreting the data shown. Where, for example, the engine and set working differ a good deal, the use of a colour in lieu of connecting lines

for the one which makes the greatest departure from the train working, will avoid the complication caused by too great a number of connecting lines. Similarly, where special shunting engines are employed, the movements of these engines can be distinguished in this way. Further refinements in the way of distinguishing, by the use of colours, carriage sets of different types, or light vehicles, such as Sentinel-Cammell coaches, etc., may be introduced as the needs of the particular case make this desirable. We must now proceed to consider the data presented in Diagram No. 6, first in some detail, so as to satisfy ourselves that the arrangements which affect the occupation of the different lines are the best that can be made, and then, with our original data adjusted in the light of any improvements we may decide are possible, the extent to which it demonstrates the need for increased accommodation, and the best way to give it.

Considering the trains in detail, there is little that calls for comment until train No. 8 is reached. Train No. 6 might, perhaps, with advantage have been run into platform No. 4 instead of platform No. 3, and stood there, in lieu of the middle line, while waiting its opportunity of crossing to the standage sidings. In this way the main line would have been free for the passage of the freight trains some minutes earlier, though a corresponding interruption to the main line would have taken place later. The outward working of trains No. 8 and No. 9, however, subject to the carriage sets being of similar composition, and the engine requirements being so nearly equal as to render them interchangeable, might have been reversed with considerable advantage. Train No. 8 could then have been run into platform No. 4, where it could have remained until required to back out and proceed to platform No. 3 and depart in the down direction, whilst train No. 9 could have arrived at and departed in the up direction from platform No. 1. In this way the down main line and platform would have been freed for approximately twenty minutes, and the up main line for

fifteen minutes, while the chances of the late arrival of either of the trains reacting adversely on the other would be considerably reduced. Unless train No. 11 were required in the sidings for cleaning or locomotive purposes, a double crossing movement could have been avoided by holding it in No. 4 platform until just before required to depart from No. 3. It is true that this would have necessitated dealing with the arrival of train No. 15 at No. 3 platform instead of No. 4. This, in turn, would have made the margin between Nos. 14 and 15 trains very small, but, if necessary, the former's demand upon the accommodation at No. 3 platform could be reduced by drawing to the up main line and backing to No. 2 platform, the engine then running round *via* the middle line.

It is a little difficult to understand why the engine of train No. 15 should, when proceeding to the shed, leave its carriages on the main line, instead of taking them to the sidings. It may be that originally the complete train was temporarily stored in the sidings, and that on some special reason arising for the engine to proceed to the shed the advantage of the complete train going was overlooked. It is true that in this case no special difficulty is caused, but the potential capacity of the station is reduced without advantage being obtained in any other direction. In the case of train No. 20, which is in many respects similar, a definite disadvantage occurs in that the occupation of the middle line by the carriage set makes it necessary for No. 23 to use the up main line for running round purposes. The outward working of trains Nos. 26 and 27 could, if engine and set working considerations permitted, be reversed with advantage. The crossing movements would then be avoided, and each train would be ready to depart approximately ten minutes earlier, to the advantage of the passengers, as well as to the relief of the accommodation.

Other questions arise from the diagram. For example, could the engine and set forming No. 15 be utilised to work the outward journey of No. 11, and the engine of the

latter thus be released for a further forty minutes for use in some other direction? Such questions as this are, however, outside the scope of our immediate consideration, and the necessary data to answer them is not given.

Let us now assume that such adjustments as have been found desirable have been made, and pass to the major question raised by our inquiry, i.e., the case, if any, for extended accommodation. It is clear from an examination of the diagram that during the peak period there is little scope for the introduction of more trains at either of the main platforms, although the maximum number of trains using either the up or down platform line during any hour is five. The bay platforms, on the other hand, have many long periods without occupation. Except, however, at stations where there is a fair proportion of turnabout trains, and facilities are provided for running round without occupying the main running lines, bay platforms are of very limited value except in so far as they enable connecting trains to be dealt with simultaneously, or afford a convenient place to stand trains which must wait a considerable time at the station, clear of the running lines.

The diagram brings out the overwhelming case in favour of the position of No. 1 platform in relation to its complementary main line platform, when compared with the position of No. 4, although the drawback of having to pass over the main line to get to No. 1 platform line is still a considerable one. A train which arrives at No. 4 is not only held there until such time as it can use the main line for a rather longer time than would have been necessary to deal with it at No. 3 platform, but the engine is rendered ineffective until the movement with the complete train can be made.

Under the conditions as they prevail at Station "K," the diagram makes it clear that the capacity of the station is in effect fixed by the through lines, and it would therefore appear to be in this direction that we must look for a solution of the problem. The final answer to it must

depend upon the extent to which it is desirable to increase the service and how far other considerations make it possible to adjust the present one when doing so. It is probable, however, that consideration of the data provided in Diagram No. 6 will already have suggested to the reader a comparatively cheap method of giving a substantial increase in capacity. The method referred to is the equipment of the middle line, at present used for shunting movements or storage purposes only, as an either way running line. This will enable the freight trains to run through the station while passenger trains are standing at the main line platforms, and enable a train to arrive at platform No. 1 while platform No. 2 is in use for another train, and still leave the middle line available for its present uses when desirable. By thus increasing the through running facilities, we should virtually be increasing the platform accommodation, because we had provided a means whereby the platform lines could be relieved.

As has been said, this simple and comparatively inexpensive improvement suggested itself after a study of the diagram. We have already drawn attention to how, in a similar way, the diagram attracts attention to the comparative uselessness of a bay platform in the position of platform No. 4. The study of a few typical diagrams, for different types of stations and traffics, will, in a similar way, indicate the comparative value of the different forms of accommodation under different traffic conditions, while the actual value to meet any particular set of circumstances can be demonstrated before expensive alterations are undertaken. For example, a similar diagram for a station where there was a good deal of exchange between trains travelling in opposite directions, which was equipped with two main through platforms and a number of running or shunting lines between them, would demonstrate that considerable advantage would arise from a rearrangement, whereby the main platforms were converted into an island, with the other through or shunting lines adjacent to the

platform lines in each direction. The degree of gain in each case would, of course, entirely depend upon the circumstances at the particular station under consideration, but a study of typical stations would at least indicate the most promising line for inquiry, after which a diagram compiled in relation to the requirements of the particular case would demonstrate the advantages that would follow the course of action selected.

Nor have we yet exhausted the uses of the diagram. Read in conjunction with the train running diagrams referred to in Chap. II, it is a convenient form in which to consider the data necessary when proposing to alter or make additions to existing train services.

CHAPTER IV

TERMINALS—PASSENGER STATION STAFF

HAVING in the previous chapter discussed the question of passenger station accommodation, and incidentally indicated a method of dealing with certain other aspects of passenger station working, it may be advantageous to follow these by a consideration of the sort of questions which arise in connection with the staffing of the station.

The habit of thought which approaches staff problems from the sole point of view of the possibility of reducing the number, or quality, of the staff employed, is by no means uncommon. As a preliminary, therefore, it is desirable to emphasise that the correct approach to staff problems, contains at least three principal considerations, and certain subsidiary ones. In the first place, it is necessary to consider whether a sufficient number of staff of the proper grades is employed, and in the second whether the duties of this number are so arranged throughout the day that the maximum effective service possible is obtained from them. The wastage in other directions which follows under-staffing may soon more than counter-balance the paybill saving obtained. On the other hand, the third consideration, namely, the removal of really surplus staff, is important, not only because it is wasteful directly, but because of its bad effect upon the morale of all the staff concerned, leading to a general lowering of the standard of the quality of service, which is bad for both employer and employee.

The principal reason for selecting the passenger station for the purpose of illustrating a staffing problem is that the

difficulties in this respect are probably greater there than at any other form of terminal. Passenger services must necessarily be arranged to suit the convenience of the purpose for which the passengers wish to travel, with the result that it is difficult to avoid a fairly substantial degree of ineffective time. A statement showing in parallel columns the number of trains dealt with, and the number of staff on duty from hour to hour, will give an approximate idea of the staff available in relation to the work to be performed, but a presentation of these data in diagram form is more likely to indicate the directions in which adjustments are desirable and possible. Diagram 7 represents the staff at station "K." The vertical lines represent time intervals, and indications are given immediately below the figures representing the hours, of the arrival and departure times of the trains at the up and down sides of the station respectively. Following these are lines representing the actual periods the different members of the station staff employed on the station platforms and platform lines are on duty. It will be seen that the diagram is so constructed as to show, on the one hand, the trains to be dealt with, as conveying a general indication of the degree of work available for the station staff; and on the other, by means of the continuous horizontal lines, broken only where a man is booked off for a meal interval, the times during which the individual members of the staff of different grades are on duty with a summary at the foot of the diagram indicating the trains to be dealt with per hour, and the total number of staff on duty during each hour. Since this is a fairly large station such members of the staff as the signalmen, whose numbers are dependent upon the importance of the signal boxes and the time they are open, and the clerical staff, who form a separate section, are omitted. In a diagram for a smaller station, where the members of the clerical or signalling staff might be called upon to assist in platform duties, they would also be included on the diagram.

It will, of course, be appreciated that the number of trains dealt with by no means represents the total work to be done

by the platform staff at the station, but it does substantially represent the work which must be done at a particular time, the majority of the remaining duties being such that they can be fitted in at convenient intervals between the trains. It will also be appreciated that the amount of work varies with different types of trains. This can, if necessary, be catered for by classifying the trains and giving them a unit value in which the work to be done is expressed, either in lieu of, or in addition to, the number of trains per hour. This, however, is a refinement which the writer has found in practice to be unnecessary, since in any case the conclusions arrived at by the study of such a diagram must be checked by a more detailed examination of the actual requirements of the particular station.

It will be noticed that the peak periods of work are between 8 a.m. and 9 a.m. and 5 p.m. and 6 p.m. respectively, which, as will be seen later, makes it difficult to staff this station without a fair margin of ineffective time, having regard to the agreement in respect to the eight-hour day which limits the interval for meals to one hour at stations of this character. As will be seen from the summary, the number of trains per hour varies between one and nine, and the number of staff on duty per hour varies between seven and sixteen, but the arrangement of the shifts is such that the higher numbers of staff on duty by no means coincide with the higher numbers of trains to be dealt with. To a large extent this is inevitable owing to the variation in the number of trains per hour. One object of our inquiry, however, is to consider whether adjustments in this respect can be made with advantage.

The general impression derived from a comparison of the hourly totals is that the station is somewhat extravagantly staffed during the lighter hours. This is by no means unusual, and the difficulties of avoiding it account for the somewhat superficial criticisms made in this respect by the travelling public from time to time when they notice a number of members of the station staff attending comparatively unimportant trains. In this particular case,

however, it will be noticed that a total staff of eleven is apparently capable of dealing with the nine trains during the peak hour, whilst during the hours between 1 p.m. and 4 p.m., when the number of trains never reaches higher than five, the number of staff is never below twelve. Moreover, in relation to the standard set during the peak hour, the numbers on duty at the beginning and end of the day, when it will be noticed there is never more than one train in the station at once, seems somewhat high. To reduce the number on duty at the beginning and end of the day by starting certain of them later, or earlier respectively, would simply result in the figures being increased during the middle of the day owing to the increased amount of overlapping, and it would therefore appear that unless, after this change had been made, some reduction in the total number of staff were possible by cutting out some of the turns in the middle of the day, the general distribution over the day would be worse than before. It is not possible, without a large amount of detail, which cannot conveniently be given here, to give a definite opinion as to how far this might be possible in a particular case, but the discussion of the position in regard to the different grades which follows may give a general idea of the sort of consideration which would lead up to such a conclusion.

The stationmaster at a fairly big station has not usually much opportunity of sharing in the actual station work, being fully occupied with the general organisation of the work, and the oversight of the remaining staff. As a rule, therefore, it will not be desirable to allocate definite platform duties to him, except for comparatively short periods, say, to cater for a peak period, when the alternative would be to employ an additional man for a whole shift. As the size of the station gets smaller, it is frequently desirable to place a fair proportion of the definite platform duties upon him in lieu of the employment of other supervisory staff. Station "K" is of sufficient importance to warrant the employment of station foremen to take general charge of the working, and since, as will be seen, it is considered

desirable to employ two foremen during the busier portions of the day, whilst two is the maximum number that is ever required to be on duty at once, the four men employed have been given straightforward shifts from 6 a.m. to 2 p.m., and 2 p.m. to 10 p.m. respectively. It can hardly be expected, however, that two men should be required during the lighter periods, especially those at the beginning and towards the end of the day, and even when any exceptional duties, such as the compilation of coaching stock and other similar returns, have been given due weight, there would still seem to be a somewhat undue proportion of ineffective time. An adjustment of the stationmaster's shift to enable him to commence one hour earlier and so cover the morning peak period, might enable one foreman's position to be cancelled, the shift of the third man being arranged in such a way as would enable him to cover the heavier middle day period and be on duty in the evening up to the time that two foremen are really necessary.

If a little further extension were necessary, this could be done by inserting meal intervals in the three different shifts at times when traffic was light, and thus strengthen the staff at the heavier periods. An alternative might be for the station foreman to perform other duties, e.g., ticket collecting, and thus enable rearrangements to be made in other grades, but in general it is better to confine the supervisory staff to their proper duties so far as this can be done without waste.

The work of the shunters bears little more than a very general relation to the number of trains dealt with, depending more upon the extent to which marshalling or remarshalling of passenger vehicles takes place. The data contained in such a diagram as Diagram 6 are a much more valuable indication of the probable demands upon the shunting staff. In passing, it may be mentioned that that type of diagram is also a valuable supplement to the one under immediate consideration, in that it gives some indication of the relative importance of the different train units.

The position in regard to the ticket collectors is much the same as that of the station foremen. If indeed two are sufficient to cater for the peak periods of nine and seven trains per hour respectively—which, having regard to normal experience, is improbable—then there would appear to be a considerable amount of ineffective time throughout the rest of the day. It is unlikely that much assistance with the ticket collecting can be given from other grades at the peak periods, because that is the time the greatest demand is made upon them, even though it is not the time of maximum availability. A later start or earlier finish of one of the two men on the early and late shift respectively would not improve matters in this respect, though it would strengthen the staff available during the noontide period, which is the next heaviest to the morning and evening periods. If, however, the four station foremen are retained, it may be that assistance could be given during the morning peak period by a station foreman, whose supervisory duties in turn could be covered by the stationmaster, whose shift would be adjusted to commence and finish one hour earlier, and during the evening peak period by a member of the platform staff. In this connection it should be remembered that the traffic during the morning and evening peak periods consists largely of regular daily travellers who, as a rule, are not accompanied by luggage.

It is not easy to draw the line of demarkation between parcels porters and platform porters, since the latter are expected to assist as necessary with both passengers' luggage and parcels. In so far as the circumstances at the particular station allow of a sufficient degree of specialisation, parcels porters are used to concentrate upon the prompt conveyance of parcels between the office and the trains, and the handling of the parcels between the delivery vans and the parcels office. Here, again, the staff at a particular station is not greatly affected by the number of trains, but rather by the importance of the parcels traffic in the area served by the station and the extent to

which it is concentrated on particular trains. On the diagram we are considering, the positions are rather of interest in so far as there may be opportunities of mutual assistance being rendered between the platform and the parcels porters. The greater number of platform porters that is usually necessary when compared with other grades often provides the greatest scope for improvement. The same sorts of considerations apply as have previously been mentioned in connection with other grades, and on the data before us the only obvious improvement that could be made would be that the hours of the seventh and eighth men could with advantage be adjusted to start two hours later, so that they might be extended to 8.30 p.m., and thus give a more even distribution over the day. Apart from its use for the purpose of periodical revisions of staff requirements, a diagram of this sort is frequently found useful as a form of recording the staff arrangements in operation at a station. The information is available in a form that can readily be grasped, and the extent to which the staff available can meet, or be adjusted to meet, temporary additional demands, can be seen at a glance, as also can the most effective way of increasing the staff should this be desirable.

CHAPTER V

TERMINALS—GOODS SHEDS

THE case of the goods shed which is apparently inadequate to meet the requirements of a developed or developing traffic is a very common one. In general, the expense of extending the area occupied is prohibitive. The problems involved in getting the maximum use out of an existing site may, therefore, be considered of special importance. It is not easy to consider them without reference to an individual case. While recognising, therefore, that traffic conditions at different places vary so widely that a discussion based on an individual case is liable to be unbalanced when considered in relation to other places, or, alternatively, to receive less consideration than it deserves, on the grounds that it was based on special considerations which do not apply generally, we have thought it well to try and illustrate the application of the principles connected with goods station working by a discussion of the working of a station designed to represent the sort of conditions which apply at many British goods sheds, and at which, with the methods of working now in existence, the traffic offering or about to be offered, is said to exceed the working capacity of the shed. In practice, this stage is rarely reached.

The most obvious way of catering for an increased traffic, i.e., by increasing the size of the shed, is not only undesirable, because of the capital cost involved, but frequently results in an increase in working costs because of the increased area extending the length of carry.

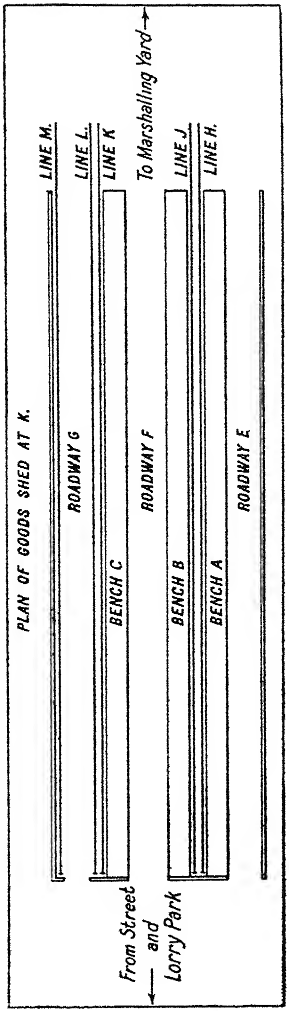
PLAN OF GOODS SHED AT K.
To Marshalling Yard
LINE M.
LINE L.
LINE K
LINE J.
LINE H.
ROADWAY G
ROADWAY F
ROADWAY E
BENCH C
BENCH B
BENCH A
From Street and Lorry Park

Diagram 8.

Generally speaking, therefore, there is a good deal to be said for making the best of the existing design, though this should not deter expenditure on structural alterations where a substantial financial return may be secured. In considering this problem, it is important to remember that the efficiency of the working depends upon (*a*) the number of times each package is handled, (*b*) the distance it has to be carried, and (*c*) the extent to which the work is up to date.

The task of organising the work at a goods shed may be divided into two fairly clearly defined parts. First, there is the arrangement of a number of what are, in effect, quite separate functions, and then the co-ordination of these functions in such a way that the staff and accommodation are both used to the best advantage. The best approach to the problem would, therefore, appear to be by way of examining the possibilities in connection with each of the separate functions in turn, with a view to discovering whether any of them can be amended or substituted with advantage.

The goods shed illustrated in Diagram 8 would not be described as of the most up-to-date type. It approximates much more nearly to the type of goods shed usually found in practice, which, more often than not, consists of the original lay-out planned before the requirements of the traffic necessitated such a large shed, and one or more extensions. Serving as it does the fairly important town situate at "K," on Diagram 1, the average daily number of inward shed wagons consists of about ninety wagons of smalls, and twenty-five wagons of full load traffic which, on account of its nature, requires to be dealt with under cover, while the outward shed traffic amounts approximately to 120 wagons a day, chiefly of smalls traffic. The shed is open for sixteen hours, the staff working alternate early (6 a.m. to 2 p.m.) and late (2 p.m. to 10 p.m.) shifts. The lines adjacent to the benches will each stand 25 wagons of average size, while 50 lorries can stand in the roadway end on the branches.

The present method of working is as follows:—Bench "A" is definitely allocated to received traffic, and bench "C" to forwarded traffic, while the middle bench, "B," is used for both traffics.

Dealing first with the received traffic: wagons containing less than wagon load consignments are placed on line "H," the contents being unloaded over bench "A" to lorries standing on roadway "E" end on to Bench "A." The town of "K" is divided into twenty-five sections for lorry delivery purposes. Bench "A" having accommodation for twice this number of lorries, it has been found to be advantageous to repeat the series of lorry sections. This, in effect, divides bench "A" into two benches, and thus reduces the average wheeling distance from wagon to lorry by half, and facilitates the work by dividing it more evenly over the bench.

Line "J" and bench "B" are used for certain wagons of perishable traffic and large lots of traffic passing regularly, which must be delivered out of turn, both of which require special cartage arrangements. The remaining inward full load traffic is dealt with on line "M" and unloaded direct from wagon to lorry. Eight gangs, each consisting of a checker, a loader, and three porters are employed on bench "A," and three similar gangs on bench "B," from 6 a.m. to about noon, during which time approximately fifty wagons of smalls, which have arrived during the night and up to that hour, can be unloaded from wagons on line "H" to the lorries standing in roadway "E," and 25 wagons of special or perishable traffic over bench "B" to lorries provided as required in roadway "F," the lorries being taken out for delivery, or to the lorry park pending their turn for town delivery, as loaded, and replaced by other empty ones. It should be mentioned here that careful tests have established that eight gangs, i.e., four gangs to each bench division, is the maximum number that can be employed on bench "A," any increase in that number leading to such congestion at and on the way to the lorries serving the busier town delivery sections that no real

advantage is gained. It will be noticed that the average rate of unloading over bench "A" is approximately one wagon per gang hour, whilst the rate over bench "B," where the delivery is much more concentrated, is approximately 1.4 wagons per gang hour. The outward full load traffic dealt with on line "M" is tallied or checked from wagon to lorry according to the requirements of the particular traffic, sufficient carting facilities and staff being provided to enable morning delivery to be given.

Passing now to forwarded traffic: Some time before 8 a.m., when this traffic begins to arrive at the station, lines "L" and "K" have been set up with empty wagons for outward traffic, use being made as far as possible of those already unloaded on "H," and the necessary staff are employed in receiving on bench "C," and loading into them, such of the outward traffic as arrives at the goods station in the morning for such wagons. It should be explained that the forwarded traffic is sufficiently regular for a high proportion of the destinations to be constant, and the positions of these regular daily wagons on lines "L" and "K" and later on lines "H," "J" and "M" have been allocated accordingly. When the unloading of the received full-load traffic is completed, empty wagons for outward loading are set on line "M," the wagons in this case being loaded direct from lorry to wagon. During the morning, when outward traffic is light, only two gangs are employed on bench "C," these consisting of checker, loader and three porters, traffic for wagons which will eventually be set on the lines adjacent to bench "B" being received on to that bench by checkers for later loading, and grouped on the bench in such a way as will, while facilitating the later loading operations, interfere as little as possible with the unloading from the inward wagons. At some time between noon and 2 p.m., depending upon the arrivals for a particular day, the whole of the shed, with the exception of bench "A" and roadway "E" is devoted to forwarded traffic purposes, the lines "J" and "H" being supplied

with empty wagons for this purpose. The method of working is now as follows:—

Benches "B" and "C" are each divided into four sections of approximately twelve wagons each, and a gang allocated to each section. The lorries conveying the traffic stop opposite the appropriate sections in turn and deliver the goods to the men working at that section, who, as far as possible, wheel them direct to the wagons, access to those on lines "H" and "L" being obtained through the centres of the wagons standing on lines "K" and "J" respectively, and over temporary gangways connecting these. On line "M" a checker is allocated to each eight wagons, who, having assisted the carter to deliver the goods to the appropriate wagon and made the necessary entries on the consignment notes, generally adjusts the loads as opportunity occurs.

In planning the outward wagon allocation, the space on the half of line "H" nearest to the exit to the shed by rail is allocated to wagons which must leave early in the evening to make their connections. When these are cleared, they are replaced by the balance of the inward wagons of received smalls, and a few gangs employed in unloading such wagons. In effect, therefore, half of line "H" and one division of bench "A" is again brought into use for received traffic. In this way, most of the wagons of received traffic still on hand waiting unloading may be cleared up with the completion of the forwarding of the outward traffic.

It will be remembered that the object of our inquiry was to consider the possibility of revising the methods of working in such a way as would enable an increase in traffic to be dealt with satisfactorily. With this end in view it is necessary to examine the different sections of the working in some detail. It does not follow that changes which enable a larger quantity of traffic to be dealt with in a given time will necessarily be desirable from the point of view of efficient working. There are cases in which increased capacity may be gained by deliberately increasing the cost

of working or adversely affecting the service given to the traffic. As a general rule, however, an increase in volume of traffic dealt with in the same accommodation should lead to greater efficiency. Clearly a combination of the three advantages is desirable if possible, and we may, therefore, keep all three in mind whilst making our inquiry.

Dealing first with the received traffic, it will obviously be necessary to find some way of unloading wagons for a longer period or at a quicker rate. We have already been told that any increase in the number of gangs employed on bench "A" will lead to inefficiency because of the congestion of barrowmen that will arise, either on the bench or at the lorries. An obvious way of increasing the rate of unloading would be to bring line "K" and bench "C" into use for this purpose. This would, however, have the serious disadvantage of increasing the necessity for benching outward traffic which arrived before the transfer from inward to outward traffic took place, and would also tend to wasteful use of the cartage facilities, especially over the lighter sections. Another alternative would be to extend the hours of working on received traffic by devoting line "H" solely to this and thus continuing to unload received traffic for the full sixteen hours. To do so would, however, adversely affect the working of the 25 wagon loads of forwarded traffic at present dealt with on line "H" during the afternoon and evening, and unless equivalent accommodation were provided elsewhere, necessitate the dumping of their contents with the consequent second handling and later departure. It would, moreover, necessitate a considerable increase in the lorry supply owing to a larger proportion being loaded during the period when delivery was not possible. The adverse effect of such an arrangement on forwarded traffic could be avoided by working a night shift, though this in turn would increase the supervision charges and necessitate the provision of extra engine power for shunting purposes.

It is, therefore, desirable that we should review this aspect of the working in some detail to see whether any

less objectionable alternative can be found. It is clear that, if it were not for the risk of congestion already referred to, an increase in the number of wagons unloaded at the same time over bench "A" would give the result we are looking for. As has already been mentioned, the present limit is fixed by the fear of congestion due to the crossing of the paths of the barrowmen, and while waiting their turn to dispose of their loads on the lorries, which will naturally occur most at those serving the busier portions of the city. To the extent that we can remove or reduce these difficulties, more gangs can be employed, and, therefore, more wagons unloaded simultaneously. Space does not permit us to go into details of the operation, but, as a first step, an examination of the town delivery sections, and the average amount of traffic for them, can usefully be made. The result of the examination in this case is given as follows:—

	Average per day				
Town delivery section.	No. of Lorries.	Weight of traffic. T.	C.	Q.	Proposed rearrangement
A	7	12	14	2	A
B	7	11	17	3	B
C	6	11	5	1	C
D	7	11	0	3	D
E	6	10	13	0	E
F	5	10	12	1	F
G	11	10	8	3	G
H	5	10	7	2	H
J	5	9	3	1	J
K	3	6	0	0	K
L	3	5	18	3	L
M	3	5	18	1	M
N	3	5	14	1	N
O	3	5	14	1	O
P	3	4	17	2	P
Q	2	3	15	0	Q
R	2	3	15	0	R
S	1	1	19	3	S
T	1	1	17	1	
U	2	1	16	0	
V	1	1	14	3	T
W	2	1	14	1	
X	1	1	0	3	
Y	1		19	1	U
Z	1		18	2	

From this it will be seen that eight of the sections are very distinctly lighter than any of the others, and that the respective densities of the remainder follow approximately the order along the bench divisions.

It is apparent, therefore, that a rearrangement can be made with advantage in more than one direction. If the town delivery sections are reduced in number and re-arranged so that the lighter section lorries may be put where they can be used in common from two bench divisions, the bench can in effect be divided into three bench divisions in lieu of the present two. Thus a reduction in number to a total of 20 town delivery sections, as indicated in the third column of the statement given, would enable the sections to be repeated three times, if five sections are used in common to two bench divisions, thus:—

Bench Division 1—Town delivery sections A to U.
,, 2 ,, ,, Q to U and A to P.
,, 3 ,, ,, L to P, Q to U, and A to K.

Some further small advantage can be gained by rearranging the remaining lorry sections so that the heavier districts are intermingled with the comparatively lighter ones, and thus spread the barrowing movements more evenly over the available space. If, with the old arrangement, a maximum of eight gangs could be employed efficiently, i.e., four gangs to each bench division, the new arrangement should enable twelve to be employed. Moreover, since the average distance of the wheel from the wagon to the lorry would be reduced a little, the gangs should either be able to work rather more quickly, or, alternatively, the number of barrowmen reduced. The capacity of bench "A" would, therefore, have been increased by one-third, and some economy made in the cost of handling, while some of the traffic would be available for delivery earlier than before.

Other incidental advantages would arise. For example, a higher proportion of wagons unloaded would be available for loading elsewhere that day. If the anticipated increase of traffic did not materialise, or did not do so sufficiently to utilise the whole of the potential increase of unloading capacity, it may be that the earlier delivery would enable the forwarded traffic to be collected earlier, and thus enable the staff to be employed in the loading of that at an earlier hour than heretofore, and so provide them with

useful employment for the balance of their shift. This, in turn, should ensure an earlier finish on forwarded traffic, thus giving a generally earlier dispatch, and in turn an earlier transfer to the unloading of any received traffic which may have arrived in the late afternoon or early evening.

The further advantage of getting this increase in capacity without bringing into use bench "C" will be apparent after an examination of the position in regard to the forwarded wagons, which we must now proceed to do. It will be remembered that the fifty wagons, standing in lines "L" and "K" and loaded over bench "C" necessitated the employment of twenty men, while the twenty-five wagons loaded on "M" required four. (In this connection it is appreciated that in both cases the number is lower than would be employed on similar work at some goods sheds, there being considerable variation according to the nature of the traffic to be handled and other local circumstances. The same standard, however, has been applied to both cases, and the proportion may be regarded as approximately correct.) In one case the lorry took the goods to the door of the appropriate wagon and the carter assisted the checker or talleyman to put them into it. In the other, they were received at a bench side by a gang consisting of a checker, a loader and three porters, who together did what was necessary to get them into position in the appropriate wagon. The difference in the cost of handing is considerable.

The direct loading method has, moreover, other advantages. A common cause of difficulty with forwarded traffic is the tendency for it to arrive at the goods station in rushes. The direct loading method is advantageous from this point of view. For the traffic dealt with over the benches there are, in effect, four unloading points per bench, and one person to receive from the carter per twelve wagons, while with the direct method there are as many unloading points as there are wagons, viz., 25, and one person to receive the goods per six wagons. It is clear

that in many cases the lorry will have to visit more unloading points, and in thus travelling farther, will take rather longer time. At rush periods, however, the gain from the reasons set out is more than sufficient to counteract this, while at slack times the other advantages far more than outweigh any loss in this direction.

There will always, of course, remain a proportion of traffic which it is desirable to load over a bench, such, for example, as that for road wagons, where the goods require to be loaded in the reverse order from that in which they will be unloaded. It is also convenient to bench traffic to a destination for which it is not certain that sufficient will arise to warrant a through wagon, until such times as a decision may be come to. In a station of the size of the one at "K" the probability is that at least 75 per cent of the wagons will be sufficiently regular to warrant daily direct loading. There would, therefore, appear to be scope for the extension of the direct loading principle at this shed, not only because of the greater efficiency, but also from the point of view with which we first approached our problem, because the direct loading has the still further advantage that the final completion and "closing" of the wagons is done in less time and the staff are thus available for transfer to the task of unloading any wagons of received traffic which may have arrived, earlier than would otherwise be the case. Line "M" is already used for direct loading. Line "L" could be used in this way, in lieu of its present use as a duplicate loading line over bench "C." This would cater for the direct loading of fifty wagons. To cater for the remainder it would be necessary to remove bench "C," replacing this by an extension of roadway "F." Should any further accommodation of this type still be required, a line of rails on roadway "F" alongside bench "B," with the rail surface flush with the roadway, would provide suitable standage for 25 more wagons after the unloading of the special received traffic over bench "B" was completed.

CHAPTER VI

MARSHALLING YARDS

DURING recent years the tendency to concentrate large numbers of wagons at one marshalling point, necessitating the extension of present, or the construction of new large, marshalling yards, has increased. The writer is a little doubtful whether this tendency is in the right direction when regard is paid to British conditions. It is at least possible that it is the result of the campaign to increase train loads, which started some years ago, before the importance of quick throughout transit was realised to the extent that it is to-day.

In general, the British trader demands what is usually called an overnight service, which means that he wishes to be in a position to hand his traffic to the railway company up to about 5 p.m. or 6 p.m. on one day, and have it at its destination by breakfast time on the following one. This, at the most, allows of, say, sixteen hours for transit purposes from the loading point to the unloading point. The loading or unloading point is normally a goods station or private siding, and it is clear that some time must be spent in collecting wagons into the marshalling yard at the originating point for forming into train loads, and, at the other end of the journey, in breaking up the train at the destination yard and putting the wagons into position for actual delivery. If we allow a total of three hours for these operations, which is certainly not excessive if regard is paid to the tendency for the greater part of such traffic movement to be concentrated round the

E

same hour, we are left with thirteen hours for the journey proper from arrival at the reception sidings of the first marshalling yard to arrival in the appropriate sorting siding of the last marshalling yard. Clearly, this leaves little margin of time to spend at intermediate marshalling yards if we are to give the desired transit, more especially if, as is normally the case, some time is necessarily occupied in marshalling at the originating yard, so as to avoid one or more stages en route.

In considering the question, other factors than the transit of traffic must be borne in mind. Marshalling yard costs vary a good deal, but the tendency appears to be in the direction of the cost per wagon handled tending to be higher as the yard becomes bigger. A still more important point, however, is the effect of time spent in marshalling yards on wagon user. The value of a wagon hour is difficult to estimate because it varies so much according to other circumstances. There can be no doubt, however, that the time spent as a result of a wagon entering a large marshalling yard often places an additional wagon day upon the round journey time, and it is unfortunate that the difficulty of assessing the value of this factor should often have led to its being overlooked or ignored when questions of train and marshalling yard working were under consideration.

To enable us to appreciate the position, let us examine the possibilities at a typical yard of fair dimensions. Let us assume that the yard consists of twenty-four sorting sidings leading from the necessary shunting neck and reception sidings, that the number of sorting sidings in the yard is such that only one siding can be allocated to each general direction to which the outward trains run, so that any sectionising must be done at the outgoing end of the yard; that the flow of traffic and layout are such that wagons can be shunted at a fairly even rate of 100 wagons per hour through the day; that train loads of wagons can be taken out of the yard at the outgoing end (with any subsidiary marshalling that may be necessary) as soon as the

train loads for the different destinations are complete; and that the average train load from the yard is forty wagons. It will be appreciated that it is quite impossible to forecast the destination order in which wagons will arrive at such a yard, and that this will vary from day to day. At some yards, there will be a tendency for wagons for certain directions to preponderate at about the same hour, but it is not, as a rule, probable that a sufficient proportion of the total wagons dealt with will do so to affect considerably the analysis of the position which follows. If we ignore such a tendency, and assume that wagons arrive at the reception sidings mixed in the same proportion as there are trains to the different destinations, we shall find on working out the case from the figures given above that the average time each wagon must spend in the sorting sidings is nearly five hours. Forty wagons would be sorted in each twenty-four minutes, but if the wagons were divided equally over the different destinations for which the yard caters, wagons sufficient for twenty-four destinations would have to pass into the yard before the first train was ready to leave, and this would occupy 9 hours 36 minutes. In so far as the flow of wagons in certain directions may be so much heavier than that for other directions, loads for the former directions would be ready in less time than this. On the average, however, approximately ten hours' shunting will be necessary to accumulate a train load, so that the average wagon will have spent five hours in the sorting sidings, quite apart from any allowance for time spent waiting its turn in the reception sidings, for any remarshalling that may be necessary or for any time lost while the train is waiting an opportunity for a path over the main running line.

At first sight it may appear that this average time will be affected favourably by wagons for destinations which accumulate more quickly than others, but the following examples will demonstrate that they only do so at the expense of wagons for other destinations, the average remaining the same.

We have previously seen that if the wagons are divided equally over the 24 destinations, the average time necessary to accumulate a train for each destination will be 9.6 hours, so that the average time a wagon spends in the sorting sidings will be 4.8 hours. In a second case, let us assume that the traffic is not divided equally between the destinations, but that four trains are formed to each of twelve of the destinations and one train to each remaining twelve. Under these conditions, a train will accumulate at the rate of once per six hours to each of the first twelve destinations and to the other twelve at the rate of once in twenty-four hours. A simple calculation from these details will show that the total wagon hours in the yard are 11,520, an average of 4.8 hours per wagon.

Taking a further case, however, let us assume that in the twenty-four hours there are four trains to each of six destinations, three trains to each of five destinations, two trains to each of eight destinations, and one train each to the remaining five destinations. The result again shows an average in the sorting sidings of 4.8 hours per wagon.

As the number of sorting sidings increases, the average train load increases, or the rate of shunting decreases, the average time the wagons will spend in the yard will increase. The reverse is, of course, equally true, and as any of these factors vary in the opposite direction, the average time spent in the yard decreases. If, for example, the yard is closed for eight hours, and the rate of shunting is increased to 150 wagons per hour in order that the same total number of wagons may be dealt with per day, the average time spent in the yard will decrease proportionately, except in so far as any balance of wagons left on hand over the period during which the yard is closed will spend an additional eight hours therein, and adversely affect the general average accordingly. Thus, on the figures previously quoted, but with the shunting speed increased to 150 wagons per hour, the average time per wagon spent in the yard, on the assumption that all the

balance of wagons are dispatched immediately shunting work ceases, is 3.2 hours. If, however, on the average, a half load for each destination is left on hand over the eight hours during which the yard is closed, this average is increased to 4.8 hours per wagon.

The only other ways in which this average time may be reduced would appear to be by increasing the rate of shunting about the time the trains are due to depart, or by arranging for traffics for the different destinations to arrive at the reception sidings immediately before the trains for those destinations are due to depart. The former is normally a matter beyond control, since it is reasonable to assume that every effort will already have been made to get traffic to the reception sidings as early as practicable, and shunt it as quickly as possible after arrival there, while the latter is difficult to arrange to any considerable extent without risk of imposing a corresponding delay to other traffic which has missed its turn for lifting from the point of origin in favour of the traffic referred to. The practical effect of this is seen in the large number of cases in which urgent traffics are given direct services from goods station yards in lieu of joining the stream of traffic to the larger marshalling yards, although in many cases it would appear that these have arisen from observation of the practical results of passing through the marshalling yards rather than because of recognition of the inevitability of considerable time being lost by so doing.

It would appear to follow, from the position, as indicated by such figures as have been quoted, that where it is judged necessary that a wagon should enter a marshalling yard, everything possible that can be done in the direction of preventing the necessity of its entering—or at the worst of its having to be sorted again at—another marshalling yard, should be done, so as to avoid any repetition of such loss of time. To put it in the form of an axiom, wagons should if possible be kept out of marshalling yards, but everything possible in the way of final marshalling should be done to those which must enter. This being so, it seems most un-

fortunate that the form of statistics selected for the purpose of testing the efficiency of the work at marshalling yards should be such as to encourage action in the opposite direction. A yard master who expects the quality of his work to be judged by the "wagons entering per engine hour employed" or "per pound of wages paid," the calculation being made on the basis that each wagon entering is accounted as one, regardless of the number of times it may be handled, must be tempted to encourage the maximum possible number of wagons to pass through his yard, and do as little as possible to them whilst there.

Returning again to the question of the case for the large marshalling yard under British conditions, let us examine the question from another aspect. If an examination is made of the total number of goods wagons forwarded each day in relation to the number of important centres in the United Kingdom—and in this connection it must be remembered that a centre served by more than one railway is for this purpose equivalent to the number of railways serving it—the conclusions, to which the figures previously quoted point, appear to be confirmed.

Taking the L.N.E.R. as an example of a railway catering for many of the heaviest industrial areas, we may say that, in round figures, 33,000 loaded goods wagons a day are forwarded from the whole of the stations on the L.N.E.R. system. If we think of a large marshalling yard in the terms of a yard that deals with 3,000 wagons per day, and on the basis that the concentration at a large yard avoids the necessity for entering other yards before arrival at destination, eleven large marshalling yards would thus cater for the whole of the loaded wagons arising. A consideration of the number of industrial centres on this line and the general geography of the system will make it clear that any attempt to concentrate these wagons, on anything approaching such an extent, must involve a considerable amount of additional haulage and seriously extend the transit time of a large number of the wagons, many of which

are loaded for haulage through complicated areas over distances so short that the necessity for entering even a small marshalling yard so prolongs the journey time as to make it appear altogether unreasonable in relation to the length of journey. It would, therefore, appear that marshalling yards on anything like the scale approaching those in use in America or on the Continent are not suitable to British conditions, and that anything in the nature of concentration yards, constructed on a bigger scale than is capable of dealing with the traffic arising in the immediate vicinity, can only be justified in a few exceptional cases. The alternative for which British conditions seem, for a large proportion of the traffic handled, to call, is for a system of sectionising at, in small yards near to, the loading point, and the planning of train services on the basis that sections are exchanged at appropriate junctions, the size of the marshalling yards being settled largely by the amount of traffic arising in their vicinity.

We will conclude the section dealing directly with marshalling yard working by a critical examination of the working of a hump yard for a period sufficiently long to be typical. We have already suggested that figures compiled on lines similar to those issued by the Ministry of Transport in respect of marshalling yard working are of little value for the purpose of providing a test of the efficiency or otherwise of marshalling yard work. Even, however, if such figures gave a correct general indication of the degree of efficiency obtained, it could hardly be expected that they would be in sufficient detail to indicate the remedy necessary to correct any shortcomings. It is clearly desirable that the yard master should be in a position to analyse the daily working at his yards. The form given, compiled to represent one day's working at the Up Yard Station "B," is a convenient way of doing this. The form is self-explanatory. From the summaries of the daily results may be compiled an average for a sufficiently long period on which to base a criticism of the working at this yard. The intermediate steps towards this are not illustrated, but the table

DAILY WORKING SHEET—"B" STATION. UP YARD—6/1/30.
ENGINE NUMBER—1600. STATE OF WEATHER—FINE.

Propelling over hump.			Running round load.		Attaching vans.		Pushing down roads.		Correcting wrong shunts.		Other causes.		
From a.m.	To	No. of wagons.	From	To	From a.m.	To	From	To	From	To	Cause	From	To
6.0	6.8	30	6.9	6.15	6.46	6.50	6.51	7.20	6.26	6.32	Waiting traffic.	7.21	7.40
6.16	6.26	35	6.33	6.38	8.31	8.35	8.10	8.30	7.56	8.10	Loco.	8.25	8.35
6.39	6.45	38	7.40	7.45	10.56	11.00	9 6	9.21	8.50	9.5	Reraling wagon.	9.36	10.0
7.46	7.55	57	8.11	8.15			10.24	10.55	10.0	10.8			
8.16	8.24	47	8.30	8.40									
8.41	8.49	53	9.21	9.26									
9.27	9 35	50	10.0	10.14									
10.15	10.23	43	11.0	11.4									
—	—	—	—	—	—	—	—	—	—		—	—	—
			a.m. 5.10	5.14					5.0	5.9			
5.15	5.23	48	5.34	5.38	5.44	5.47	5.24	5.33					
5.39	5.43	27					5.48	6.00					
TOTAL OPERATIONS			41		7		24		20				

SUMMARY.

												Waiting Traffic Min.	Loco. Min.	Other causes. Min.
	H.	M.		H.	M.	H.	M.	H.	M.	H.	M.			
1st Shift	2	57	873	1	5		20	2	23	1	5	19	20	24
2nd Shift	2	45	864	1	0	—		2	5		55	—	30	—
3rd Shift	2	25	793	.	50		12	2	53	1	2	10	20	—
TOTAL	8	7	2,530	2	55		32	7	21	3	2	29	70	24

below gives the final result in a form which lends itself to the object in view:—

Statement giving an analysis of the working at "B" Yard, four weeks ended 1.2.30.

	Average per working day hrs.	min.	Per cent.
Shunting engine hours	24	0	100
Time occupied:			
(*a*) Propelling over hump	8	20	34.7
(*b*) Running round loads	2	45	11.2
(*c*) Attaching vans		30	2.1
(*d*) Pushing down roads	7	15	30.0
(*e*) Correcting wrong shunts	3	5	13.0
(*f*) Engine (loco. time)	1	10	5.0
(*g*) Waiting traffic		30	2.1
(*h*) Other causes		25	1.7

Number of loads dealt with	42
Average time running round loads	4 minutes
Total wagons dealt with	2,507
Average wagons dealt with:	
(*a*) per engine hour	104
(*b*) per propelling hour	302
Average time occupied attaching vans ...	2.7 minutes
Number of occasions pushing down roads ...	23
Average time occupied pushing down roads	19 minutes
Wrong shunts corrected	19
Average time occupied	10 minutes

Like every such table that the writer has seen, this one draws attention to the small proportion of effective time, i.e., time spent in actually sorting wagons over the hump, a feature which attracts attention to the superiority of the purely gravitation yard in this respect and raises the question as to whether the additional cost of construction and haulage involved where the natural contour of the land does not lend itself to this, would be more than counter-balanced by the increased effectiveness of that type of yard. For our present purpose we have accepted the common assumption that the hump yard is superior, and must, therefore, confine our consideration to the possibility of obtaining more effective use out of that type.

If we refer to the statement which gave an analysis of the working at the Up Yard at station "M," we notice that

when the items of time occupied propelling over hump, running round loads, and attaching vans, lettered (a), (b), and (c) respectively, are taken together, they form only 48 per cent of the total time the shunting engine is available, and that, between them, "correcting wrong shunts," and "pushing down roads" account for the greater proportion of the remaining 52 per cent, which may be described as ineffective time.

It will be appreciated that, as a rule, the wrong shunt is not the result of a mistake on the part of the chalker or pointsman, but is due to the fact that, for one reason or another, a sufficient gap has not been created between the succeeding wagons, by the time they are reaching the points where the lines to their respective sorting sidings diverge, to enable the points for the second wagon to be operated in the way that would direct it into the right sorting siding, because of the risk of its catching up to the first one, and lock buffering or derailment resulting. The necessity for time to be spent in pushing down roads is caused by wagons having come to rest in the sorting sidings before they have travelled the full distance the space available in the sorting siding will allow, and thus make it impossible for additional wagons safely to enter that siding before the wagons in it are pushed to the places to which it was originally intended they should go. Both these difficulties may be due to

(*a*) An insufficient number of brakesmen being employed in relation to the rate of working, or to bad judgment or carelessness on the part of those employed in dealing with wagons of varying weights and freedom of running,

or

(*b*) The rate of propulsion over the hump being too fast for the layout.

Dealing with the latter first: the two principal features in connection with the layout, on which the efficiency of a hump yard appears to depend, are the gradient leading from the hump to the sorting sidings, and the arrangement

of the clearance points to the different sorting sidings. The correct gradient between the crown of the hump and the clearance points must be settled by a compromise between two conflicting considerations. Regarded solely from the point of view of getting the maximum number of wagons over the hump and clear into the sortings sidings in a given time, the steeper the fall of the hump line the better, because the rate at which the wagons can be propelled up to the crown of the hump depends upon the time necessary for each succeeding wagon, by the combined effects of the forces of gravity and momentum, to create a sufficient interval between it and the following wagons for the latter to be clear at the clearance points into the respective sorting sidings.

With wagons whose weight and ease of running are equal, this interval must be created during the time taken from the point at which the preceding wagon comes under the influence of the downward gradient and the next succeeding wagon reaching that point. If this were the only consideration, the gradient could be so steep that the wagons would enter the sorting sidings at such a speed that they would be uncontrollable by hand braking, or even by mechanical braking, without using such force as would damage the wagon and its contents. The gradient of the hump line must, therefore, be modified to the extent necessary to reduce the speed to that at which the wagons may be brought under control by whatever form of braking is in use, and without damage to the wagons or their contents. As the gradient is reduced a longer time will be necessary to enable the necessary interval between the succeeding wagons to be created, thus involving a slower rate of propelling up to the crown of the hump. Practice appears to have shown that the speed at which British wagons can be controlled by hand braking is a safe speed from the point of view of avoidance of damage to a wagon or contents by braking. There has not yet been sufficient experience of mechanical braking to say of what additional speed this will safely allow. The question is complicated by the fact of the

gradient of the hump being fixed, while the weight and ease of running of individual wagons, and also the number of wagons in the cut, vary very considerably, and in practice the rate of propelling over the hump has to be settled by the capacity of the slowest running wagon to get sufficiently far ahead of the fastest running wagon that may follow it.

To some extent faster working than would otherwise be possible can be attained by checking the easier running wagon by brake before reaching the clearance point, but this is an operation that needs to be done with considerable judgment, otherwise the next succeeding wagon will take advantage of the check to reduce the interval in such a way that it is too small to enable it to be turned into its correct siding thus creating the necessity to waste time correcting the consequent wrong shunt. The practice of taking a few minutes longer in propelling a load over the hump is a sound insurance against the long period necessary for correcting the wrong shunts which are liable to result from an undue speeding up in this respect. If, in spite of a slow propelling speed, frequent braking is necessary before the clearance points to the sorting sidings are reached, it may safely be assumed that the gradient of the hump requires adjustment, or that the layout of the lines between the hump and the clearance points is unsatisfactory.

What has been said above emphasises the importance of the distances between the crown of the hump and the clearance points to the respective sidings being equal, the distances being expressed in terms of the time a similar wagon will take to travel from the crown of the hump to the clearance point, allowance thus being made where the necessary curvature will tend to check the wagons. In so far as they are not, the gradient from the hump and the rate of propelling must be settled according to the longest clearance point, since otherwise wrong shunts are almost sure to follow the passage of wagons into the sidings requiring the bigger intervals owing to the braking neces-

sary to the following wagons before the clearance point is reached.

Apart from the adverse effect of unsuitable layout and/or propelling speed that is not in unison with it in causing wrong shunts, it is also liable to affect the degree to which it is necessary to spend engine time in pushing down roads. A gradient that is so steep that the speed attained by the heavier and easier running wagons or sets is such that control by hand brake after reaching the sorting sidings is difficult, is liable to cause the brakesman to apply the brake with too severe effect. This may check the wagon to such an extent that, even if he has time to release the brakes before it is necessary to attend to the following one, and before the previous one actually comes to a stand, it will not travel the full distance for which the appropriate siding is clear. An under-supply of brakesmen, or insufficiently skilled or careless brakesmen, is liable to have a similar effect. The position can be eased by a suitable arrangement of the gradient in the sorting sidings after the clearance point is passed.

It will be noticed that the proportion of time spent in correcting wrong shunts and pushing down roads is no less than 43 per cent of the total, so that there is considerable scope for increasing the capacity of the yard by improving the layout in the two respects mentioned.

Apart from the time spent waiting traffic, a considerable proportion of ineffective time would appear to be inherent to hump yard working except in so far as it can be avoided by duplicating the engine power. The fact that such ineffective time is not inherent to purely gravitation yards is a further argument in their favour. A corresponding loss would occur with a flat yard, whether the reception sidings were arranged in tandem or by the side of the sorting siding. In addition to the features to which attention has already been directed, the table draws attention to the general standard that is being achieved in the different sections of the work, which, though comparatively unimportant in relation to the principal causes of inffective

time, is still important in that a few minutes wasted on each occasion that such an operation as, say, running round a load is performed, mounts up in the course of a shift to an appreciable percentage of the total effective time, and will frequently make the difference of upwards of a hundred additional wagons being dealt with.

In cases where there are considerable gaps waiting traffic, the statement is a valuable pointer as to the case for investigation with a view to earlier arrivals, or if this is found to be impossible, and the transit of the traffic will not suffer by it, of slowing down the rate of propelling over the hump below that necessary for working the yard at its full capacity, and so enabling a saving in brakesmen to be effected.

CHAPTER VII

PASSENGER TRAIN WORKING

IT will be convenient to illustrate methods of arranging and revising engine "workings"—as the grouping together of the various trips for convenience and economy of working are called—and to follow this by a consideration on similar lines of the trainmen's and carriage set working, all of which are to some extent inter-dependent, by combining these with an illustration of the advantages to be derived by the introduction of an "interval" passenger train service, for a section of the line shown on Diagram 1. The methods illustrated can be applied with equal advantage to freight trains.

To enable the question to be dealt with on these lines within reasonable limits of space, it will be necessary to take a very simple illustration, and the case must not, therefore, be taken as representing a full picture of the difficulties of revising a typical passenger train service. For example, it is necessary for the reason indicated to regard the working as a self-contained one, a condition which would rarely be found in practice, and to leave off our consideration at the stage where the consideration of the effect of the proposals on connecting trains at any junctions concerned would begin, a factor which frequently distinctly limits the scope for advantageous alteration. It is hoped, however, that it will be sufficient to indicate the type of difficulty which must be overcome and the methods which have been found useful in helping to do this, for it is in respect to the number of such difficulties, and the extent to which the choice of action in different directions is liable to react in others,

PRESENT SERVICE OF PASSENGER TRAINS BETWEEN B AND H.

TRAIN NO.	1	2	3	4	5	6	7	8	9	10	11	12	13
	a.m.	a.m.	a.m.	a.m.	a.m.	p.m.	p.m.	p.m.	p.m.	p.m.	p.m.	p.m.	p.m.
B ... ... dep.	7. 4	8.23	9.10	10.10	11.27	12.30	1.30	2.17	3.55	4.45	5.30	6.15	8.30
Station 1 ... ... „	7.14	8.33	...	10.20	11.37	...	1.40	...	4. 5	...	5.40	...	8.40
„ 2 ... ... „	7.23	8.42	...	10.29	11.46	...	1.49	...	4.14	...	5.49	...	8.49
„ 3 ... ... „	7.33	8.52	...	10.39	11.56	...	1.59	...	4.24	...	5.59	...	8.59
„ 4 ... .. „	7.41	9. 0	...	10.47	12. 4	...	2. 7	. .	4.32	...	6. 7	...	9. 7
H ... ... arr.	7.49	9. 8	9.43	10.55	12.12	1. 3	2.15	2.50	4.40	5.18	6.15	6.48	9.15

TRAIN NO.	14	15	16	17	18	19	20	21	22	23	24	25	26
	a.m.	a.m.	a.m.	a.m.	p.m.	p.m.	p.m.	p.m.	p.m.	p.m.	p.m.	p.m.	p.m.
H ... ... dep.	7.37	8.30	9.15	11. 5	12. 5	12.23	5.15	3.25	5.10	5.25	7.10	7.30	8.23
Station 4 ... ... „	...	8.35	...	11.10	...	12.28	2. 0	...	5.15	...	7.15	...	8.28
„ 3 . . ... „	...	8.45	...	11.20	...	12.38	2.10	...	5.25	...	7.25	...	8.38
„ 2 ... ... „	...	8.56	...	11.31	...	12.49	2.21	...	5.36	...	7.36	...	8.49
„ 1 ... ... „	...	9. 6	...	11.41	...	12.59	2.31	...	5.46	..	7.46	...	8.59
B ... ... arr.	8.10	9.15	9.48	11.50	12.38	1. 8	2.40	3.58	5.55	5.58	7.55	8. 3	9. 8

that the illustration used must be regarded as having shortcomings.

The section of the line taken for this example is the line "BH" on Diagram 1, consideration being confined to the five express and eight slow trains from "B" to "H" and the six express and seven slow trains from "H" to "B," which together form what may be described as the local service; this excludes the fourteen expresses, eight in one direction and six in the other, which pass over this line as part of a long-distance service between points beyond "A" and "D" respectively. The details of the local service between "B" and "H" are given in time-table form on page 72, the trains having been numbered for easy reference.

The engine and enginemen's workings at present in operation are as follow:

ENGINE AND ENGINEMEN'S WORKING.

B. SHED.

ENGINE 1.

	Arr. a.m.	Dep. a.m.
B	—	7. 4
H	7.49	8.30
B	9.15	10 10
H	10 55	12. 5
B	12.38*	1 30
H	2.15	3.25
B	3.58	4.45
H	5.18	7.10
B	7.55	—

* Enginemen change.

ENGINEMEN.	1st Set.	2nd Set.
Sign on	5.45 a.m.	1. 0 p.m.
Sign off	1.45 p.m.	9. 0 p.m.

ENGINE 2.

	Arr. a.m.	Dep. a.m.
B	—	6.45 LE†
H	7.15	7.37
B	8.10	9.10
H	9.43	11. 5
B	11.50	12.30
H	1. 3	1.55
B	2.40*	3.55
H	4.40	5.25
B	5.58	8.30
H	9.15	9.20 LE
B	9.50	—

* Enginemen change.

† Engine prepared by No. 1 turn 1st Set.

ENGINEMEN.	1st Set.	2nd Set.
Sign on	6.35 a.m.	2.40 p.m.
Sign off	2.45 p.m.	10.40 p.m.

ENGINE 3.

		Arr.		Dep.
		a.m.		a.m.
B	...	—	...	8.23
H	...	9. 8	...	9.15
B	...	9.48	...	11.27
H	...	12.12	...	12.23
B	...	1. 8*	...	5.30
H	...	6.15	...	8.23
B	...	9. 8	..	—

* Enginemen change.

ENGINEMEN.	1st Set.	2nd Set.
Sign on	7.23 a.m.	1.20 p.m.
Sign off	1.23 p.m.	9.20 p.m.

ENGINE 4.

		Arr.		Dep.
		p.m.		p.m.
B	...	—	...	2.17
H	...	2.50	...	5.10
B	...	5.55	...	6.15
H	...	6.48	...	7.30
B	...	8. 3	...	—

ENGINEMEN.	
Sign on	1.17 p.m.
Sign off	9.17 p.m.

It will be noticed that, as at present arranged, the service given above requires the use of four locomotives, three of which are double-shifted, i.e., are kept in steam for a period sufficient to necessitate two shifts of enginemen being employed, making seven sets of enginemen in all. Any consideration of a revised train service also raises the question of the carriage and guards' working. To make our data complete, therefore, so that the costs of any changes which are proposed may be compared at a later stage, these are also given:

CARRIAGE WORKING.

SET 1.

		Arr.		Dep.
		a.m.		a.m.
B	...	—	...	7. 4
H	...	7.49	...	8.30
B	...	9.15	...	10.10
H	...	10.55	...	11. 5
B	...	11.50	...	12.30
H	...	1. 3	...	1.55
B	...	2.40	...	3.55
H	...	4.40	...	5.10
B	...	5.55	...	6.15
H	...	6.48	...	7.30
B	...	8. 3	...	8.30
H	...	9.15	...	—

Forms Set 2 next day.

CARRIAGE WORKING—(*Contd.*)

SET 2.

		Arr. a.m.		Dep. a.m.
H	...	—	...	7.37
B	...	8.10	..	8.23
H	...	9. 8	.	9.15
B	...	9.48	..	11 27
H	...	12.12	..	12.23
B	...	1. 8	...	1.30
H	...	2.15	...	3.25
B	...	3.58	.	4 45
H	...	5.18	...	5.25
B	...	5.58	...	6.15†
H	...	6.48†	..	8.23
B	...	9. 8	...	—

Forms Set 1 next day.

SET 3.

		Arr. a.m.		Dep. a.m.
B	...	—	...	9.10
H	...	9.43	..	12. 5
B	...	12.38	..	2 17
H	...	2.50	...	3.25†
B	...	3.58†	...	5.30
H	...	6 15	...	7.10
B	...	7.55	...	—

† Empty.

GUARDS' WORKING.

TURN No. 1.

Sign on at B 6.50 a.m.

		Arr. a.m.		Dep. a.m.
B	...	—	...	7. 4
H	...	7.49	...	8.30
B	...	9.15	..	10.10
H	...	10.55	...	11. 5
B	...	11.50	...	12.30
H	...	1. 3	...	1.55 assistant.
B	...	2.40	...	—

Sign off at B 2.50 p.m.

TURN No. 2.

Sign on at B 11.10 a.m.

		Arr. a.m.		Dep. a.m.
B	...	—	...	11.27
H	...	12.12	...	12.23
B	...	1 8	...	1.30
H	...	2.15	...	3.25
B	...	3.58	...	4.45
H	...	5.18	...	5.25
B	...	5.58	...	—

Sign off at B 7.10 p.m.

TURN No. 3.

Sign on at B 2.0 p.m.

		Arr. p.m.		Dep. p.m.
B	...	—	...	2.17
H	...	2.50	...	3.25 assistant.

GUARDS' WORKING—(*Contd.*)

		Arr.		Dep.
		a.m.		a.m.
B	...	3.58	...	5.30
H	...	6.15	...	7.10
B	...	7.55	...	—
Sign off at B	10.0 p.m.			

TURN No. 4.
Porter Guard.

		Arr.		Dep.
		a.m.		a.m.
B	...	—	...	9.10
H	...	9.43	...	12 5
B	...	12.38	...	—

TURN No. 5.
Porter Guard.

		Arr.		Dep.
		p.m.		p.m.
B	...	—	...	6.15 assistant.
H	...	6.48	...	8.23
B	...	9. 8	...	—

TURN No. 6.
Sign on at H 7.20 a.m.

		Arr.		Dep.
		a.m.		a.m.
H	...	—	...	7.37
B	...	8.10	...	8.23
H	...	9. 8	...	9.15
B	...	9.48	...	10.10 assistant.
H	...	10.55	...	—
Sign off at H	3.20 p.m.			

TURN No. 7.
Sign on at H 1.30 p.m.

		Arr.		Dep.
		p.m.		p.m.
H	...	—	...	1.55
B	...	2.40	...	3.55
H	...	4.40	...	5.10
B	...	5.55	...	6.15
H	...	6.48	...	7.30
B	...	8. 3	...	8.30
H	...	9.15	...	—
Sign off at H	9.30 p.m.			

The carriage roster and guards working shown above indicate that three sets of carriages are in use, while five guards, three stationed at "B" and two at "H," are employed for full shifts, one of whom is available for approximately four hours' platform work at "H"—leaving certain trips to be worked by porter guards owing to the impossibility of combining them to greater advantage—making altogether a total of guards' time equivalent to rather more

than another full shift, a net total of approximately five and a half guards' shifts per day.

It is not, of course, either necessary or desirable to confine the possibility of revising to advantage the engine, carriage, or trainmen's working to occasions when the actual train services are under revision. As with freight trains, the motive for the revisions of passenger services may be either a demand for an improved service or an attempt to work an almost equivalent service more economically, and most services and workings have evolved as a result of a series of small alterations or additions to the original schemes. Any revision of the train service is necessarily accompanied by a revision of the other workings so far as these may be affected by any changes that are made, but it is easy—especially when, as is often the case, alterations are made at short notice—to miss opportunities for making improvements which a general review of the whole of a working will bring to notice.

Although the more constant character of passenger traffic obviates the need for a general revision of the passenger train services so frequently as is desirable in the case of freight trains, equally frequent periodical examinations should certainly be made of the various workings which are necessitated by them. The most satisfactory way which the writer has found for indicating promising cases for inquiry is to compare the hours during which remunerative work is carried on with the total hours occupied. If this is done in the case we are considering, we get the following results:—

Total time of train journeys	17 hrs. 18 mins.
Total time engines in steam, excluding preparing and stabling	46 hrs. 27 mins.
Total time enginemen on duty	56 hrs.
Three carriage sets in use, a total of ...	38 hrs. 27 mins.
Total time guards on duty	47 hrs.

It will be noticed that in each case there is a large proportion of ineffective time. In saying this it must not, of course, be taken that the whole difference between the total time of the train journeys and the remaining figures quoted

can strictly be regarded as non-effective time. For example—the locomotive requires certain attention before and after journeys are completed and at intervals between the trips; the carriages time for cleaning, for the passengers to join and leave the train, and for the luggage, parcels, etc., to be loaded and unloaded, and so on, and, if preferred, the necessary allowance may be added before making the comparison. Since, however, these factors will tend to be fairly constant, and the comparison is merely for the purpose of indicating the cases where the gap between the effective and total time is sufficiently abnormal to indicate a promising field for inquiry, it is not essential to do so.

As it is proposed at a later stage to compare the present service with a suggested interval service, it is desirable that we should at this stage make any adjustments which can with advantage be made to the present workings, in order that a proper comparison between the two sets of conditions may be made.

In advocating the use of diagrams for this and similar purposes, it is desirable that a caution should be given against making the diagrams too elaborate. So long as a diagram is sufficiently neat for its message to be conveyed it meets all real requirements. It is at least possible that much of the criticism of the use of diagrams, and the statements which are frequently made that the advantages gained by their use are not worth the trouble of compilation to the practical man, are due to a tendency in the opposite direction. In the majority of cases, all the data that it should be necessary to plot on a diagram used for purposes of this sort can be inserted in freehand, and it is usually an advantage to work in pencil, at any rate in their earlier stages to allow of easy erasure.

When planning workings for new services or revising old ones which are at all complicated, two stages of diagram are desirable, and although they are not necessary in the comparatively simple case we are considering, the two stages have been worked out for guidance in more compli-

cated cases. In the first stage the trips are indicated in time order in such a way as to enable one to see at a glance the best way to connect them up to obtain the most advantageous working. To do this, the whole of the trips which start from or finish at each of the different centres must be indicated on the diagram in relation to each centre, and although this necessitates each trip being shown twice, since it must appear as arriving at one point and departing from another, this does not, in practice, cause difficulty. It would, moreover, appear to be the best way of ensuring that all the possible connections between the different trips are most easily seen, so that the choice may be made which will give the greatest advantage.

Applied to the service quoted, the accompanying diagram (Diagram 9) represents the trips between "B" and "H." In the more complicated cases in which more than two centres are affected, it is desirable that they should be placed on the diagram in approximately geographical order. Thus, for example, if workings which affected centres "A," "B," "H," "K," "J," and "C," were under review, a convenient order would be "C," "A," "B," "H," "K," "J," though the positions of "C" and "J" might have to be changed if the streams of traffic were different in volume from those shown in Diagram 1.

The next stage is to assemble the separate trips in such a way as will build up the different workings to the best advantage, keeping in mind the appropriate terminal requirements.

Where, as in this instance, there is an engine working in existence, and the case is a comparatively simple one, the first stage can be omitted, and the possibilities may be considered from a diagram prepared direct from the figures shown in the engine working; though there is much to be said, in this as in many other problems, for starting *de novo,* and then reconciling to the best advantage the differences between the conclusion and what is already in operation. As, however, we shall have an opportunity of doing this when an altered train service is considered, we

will adopt the second method in this case. Diagram 10, therefore, has been compiled from the engine working quoted.

On broad lines it may be stated that, within the limits imposed by the standard 8-hour day for the enginemen, the objects in arranging an engine working are, first, to meet the requirements with a minimum number of engines in steam, and then to reduce to the minimum the number of hours the engines are in steam. Looking at Diagram 10 from this point of view, it will be seen that Trip 8 can be transferred to No. 3 engine, which can return to "B" coupled to No. 1 engine when the latter works Trip 21, so as to be ready at "B" to take up its next trip, and that Trips 12 and 25 could be inserted between Trips 22 and 13, and worked by No. 2 engine. It does not, however, appear to be possible to provide for Trip 22 without calling out a fresh engine, which would have to travel light between "B" and "H" either before or after working this trip. The effect of these changes would be to reduce the total engine hours in steam, excluding the time necessary for preparing and stabling—of 46 hours 27 minutes by approximately four hours. Other minor changes might be made, but limitations of space make it desirable we should assume that this represents the only substantial improvement possible to the engine working, and that consideration of the other workings on similar lines confirms the correctness of the present arrangements. The student may find it interesting to examine them in more detail.

We must pass on to consider how far adjustments to the service given can be made, with the object of improving the service or effecting economies, or both. This might be done by considering, in the light of the information afforded by engine working Diagram 10 and of similar diagrams representing the guards' and carriage working, the opportunities that alterations to certain trains might offer in these directions. For the reasons given, however, a complete revision of the service, with a view to substituting a service on an interval basis, will now be considered.

In introducing such a service, the interval between the successive trains and the actual times at which the trains shall depart will necessarily be fixed according to the requirements of the particular case. If it is considered that a more frequent service will attract sufficient passengers to justify this, then, clearly, a shorter interval will be selected, but as a rule it is probably wise, in the first place, to aim at a service a little more than approximately equivalent to the existing one. Similarly, in regard to the times chosen for departure, there is some advantage from the public point of view in selecting a time that is easily remembered, the exact hour being the ideal. This must, however, be affected to some extent by the requirements of the public as demonstrated by the service which is already in existence, and the possibilities in connection with the occupation of the platform and running lines concerned.

Examining the service already quoted from this point of view, the revised time-table, shown on page 82, has been compiled, which, whilst giving one additional train in each direction and providing trains at regular hourly intervals at thirty minutes past the hour, maintains a good many of the present trains at very nearly the present times.

It may be, of course, that there are good reasons why certain of the train times shown in the proposed new time-table are not so suitable to potential users as some of those they replace; in such circumstances, it might be desirable to make some slight adjustment, even at the cost of departing from the interval principle, as, indeed, the careful reader will have noticed has been done with the order of express and slow trains respectively.

For our purposes, however, we will assume that the new service is likely to be at least as satisfactory to the travelling public as the old one. It is desirable, therefore, to prepare the necessary engine, enginemen's, carriage and guards' working, so that the cost these represent may be compared with that of the service at present in operation.

The first step is to prepare a "trip" diagram, on the lines described, showing the trips in relation to their arrival and

PROPOSED SERVICE OF PASSENGER TRAINS BETWEEN B AND H.

Train No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	a.m.	a.m.	a.m	a.m.	a.m.	p.m.	p.m.	p.m.	p.m.	p.m.	p.m.	p.m.	p.m.	p.m.
B ... . dep.	7.30	8.30	9.30	10.30	11.30	12.30	1.30	2.30	3.30	4.30	5.30	6.30	7.30	8.30
Station 1 . ... „	7.40	8.40	.	10.40	11.40	. .	1.40		3.40	.	5.40		7.40	8.40
„ 2.. .. .. . „	7.49	8.49	.	10.49	11.49	...	1.49		3.49	..	5.49	.	7.49	8.49
„ 3 .... „	7.59	8.59	.	10.59	11.59		1.59	.	3.59	..	5.59	.	7.59	8.59
„ 4 .. . . „	8. 7	9. 7	.	11. 7	12. 7		2. 7	..	4. 7	.	6. 7	...	8. 7	9. 7
H . .. . arr.	8.15	9.15	10. 3	11.15	12.15	1. 3	2.15	3. 3	4.15	5. 3	6.15	7. 3	8.15	9.15

Train No.	15	16	17	18	19	20	21	22	23	24	25	26	27	28
	a.m.	a.m.	a.m	a m.	a.m.	p.m.	p.m.	p.m.	p.m.	p.m.	p.m.	p.m.	p.m	p.m.
H .... dep.	7.30	8.30	9.30	10.30	11.30	12.30	1 30	2.30	3.30	4.30	5.30	6.30	7.30	8.30
Station 1 . ... „	...	8.35	.	10.35	11.35	..	1.35	2.35	..	4.35	5.35	. .	7.35	8.25
„ 2 . „	.	8.45		10 45	11.45	...	1.45	2.45	. .	4.45	5.45	...	7.45	8.45
„ 3. .... „		8.56		10.56	11.56	...	1.56	2.56	.	4.56	5.56	.	7.56	8.56
„ 4 ... .. „	..	9. 6	.	11. 6	12. 6	.	2. 6	3. 6		5 6	6. 6	. .	8. 6	9. 6
B ... . . . arr.	8. 3	9.15	10. 3	11.15	12 15	1. 3	2.15	3.15	4. 3	5 15	6.15	7. 3	8.15	9.15

departure from the different centres, so as to see clearly the best way of linking them up into the different workings. This has been done, the result appearing as on Diagram 11.

Taken together, the costs of the locomotive and enginemen represent the greater part of the direct cost of train working, that of the enginemen naturally being dependent to a large extent on the work assigned to the different engines. This being so, the arrangement of the engine and enginemen's working should take precedence over that of the remaining workings. The next step, therefore, is to plan the engine working, making use of the trip diagram. In doing this, it will be necessary to keep in mind the need for the engine to run round the train set at terminal points, or, alternatively, where the carriage working does not follow the engine working, for it to travel to and be attached to its new set. Opportunities for taking water and other locomotive duties must also be provided as necessary. Where a choice is available without additional engine time being incurred, the value of having reasonably long intervals between trips for the purpose of recovering from any effects of late running on earlier ones should not be overlooked.

Following the trip diagram, we see that the engine working trip 1 from "B" to "H" can conveniently work trip 16 back to "B," to be followed by trips 3, 18, 5, 20, and so on, and, as these are transferred from the trip diagram to the draft of the engine working diagram, an indication should be made on the former to show that the trip has been provided for. Having exhausted the possibilities of the first engine in steam, the trip diagram should again be gone through to cater for the remaining trips, and the first draft of the engine working diagram is thus completed and now appears as Diagram 12.

This first draft, which, it should again be emphasised, is normally considerably more complicated than the one which is here reproduced, now requires careful examination, so that advantageous adjustments can be made. Accepting Diagram 12 as affording no scope in this direction, we notice

that the whole of the new service can be catered for by two engines in steam, with a minimum interval of fifteen minutes and occasional intervals of twenty-seven minutes at terminals. Without allowing for shed duties, the two workings cover 13¾ hours. Each will therefore require two sets of men, and there will be little waste. We are now in a position to set out the engine working in the form in which it normally appears, and do so as follows:

PROPOSED ENGINE WORKING.

ENGINE 1.

		Arr.		Dep.
		a.m.		a.m.
B	...	—	...	7.30
H	...	8.15	...	8.30
B	..	9.15	..	9.30
H	.	10. 3	.	10.30
B	...	11.15	...	11.30
		p.m.		p.m.
H	...	12 15	...	12.30
B	...	1. 3*	...	1.30
H	...	2.15	...	2.30
B	...	3. 3	...	3.30
H	...	4.15	...	4.30
B	...	5 15	...	5.30
H	..	6.15	...	6.30
B	.	7. 3	...	7.30
H	..	8 15	...	8.30
B		9.15	...	—

ENGINEMEN.	1st Set.	2nd Set.
Sign on	6.30 a.m.	1.20 p.m.
Sign off	2.30 p.m.	9.20 p.m.†

ENGINE 2.

		Arr.		Dep.
		a.m.		a.m.
B	...	—	...	6.50 LE
H	..	7.20	...	7.30
B	...	8. 3	...	8.30
H	...	9.15	...	9.30
B	..	10. 3	...	10.30
H	...	11.15	..	11.30
		p.m.		p.m.
B	...	12.15	...	12.30
H	...	1. 3*	...	1.30
B	...	2.15	...	2.30
H	...	3. 3	...	3.30
B	...	4. 3	...	4.30
H	...	5. 3	...	5.30
B	...	6.15	...	6.30
H	...	7. 3	..	7.30
B	..	8.15	...	8.30
H	...	9.15	...	9.20 LE
B	...	9.50	...	—

ENGINEMEN.	1st Set.	2nd Set.
Sign on	6.15 a.m.	2.0 p.m.
Sign off	2.15 p.m.	10.0 p.m.†

* Men change. † Relieved on arrival.

At this stage, at which the carriage and other workings have not been prepared, it may not be possible to settle the engine requirements finally, and the proposals must be regarded as provisional until the carriage and other workings have been drafted, when the engine working will require to be re-examined in the light of the proposals in those directions and the requirements for platform accommodation at the terminal stations.

A re-examination of the trip diagram from the point of view of the carriage working should now be made. In many actual cases it would be found that the carriage working could with advantage differ from the engine working. In this case it is clear that a minimum of two carriage sets will be required, as the trains pass each other *en route*. Except in very exceptional circumstances, such as apply at terminal stations where the conditions demand the quickest possible turn-round of trains, it is clearly an advantage for the carriage working to follow the engine working if this can be done without costs in other directions which more than offset such advantages.

A reference to the engine working diagram under consideration will make it clear that, if the second set is arranged to start and finish at "H," this can be done throughout without incurring light mileage, or, assuming, as we have done, the conditions at the terminal stations will allow of this, without other difficulties. The principal cleaning of both sets will require to be done at the beginning or end of the day, and there are opportunities for sweeping and dusting during certain of the periods when the sets will be at terminal stations. In a similar way, the guards' working can, in this case, follow engine, enginemen's and set working, the difference being that the guards who work with the second set can be stationed at "H," and, since neither first shift guard will require to sign on duty until shortly before the time he is required to work his first train, say, at 7.15 a.m., the demand for guards' time on each series is 14¼ hours, as compared with the sixteen hours for which two guards will be available. To use up this spare

time and to enable the change to be made at the home station, the first guard can finish his train duties at 1.20, and be available for other platform duties until his signing-off time at 3.15 p.m.

In dealing with the matter in this way, we have not only ensured that the train service is provided in the way that is least costly, but that the personnel and vehicles concerned are, as far as possible, kept in continuous employment. A comparison between the cost of the original and that of the revised service is of interest, and is as follows:

	Present.	Proposed.	Difference.
Engines in steam—			
Number	4	2	−2
Total (hours)	41½	28¾	−12¾
Shifts of enginemen	7	4	−3
Carriage sets in use	3	2	−1
Shifts of guards (equivalent to)	6	4	−2

It will be seen that, although an additional train is provided in each direction, the reduction in cost of providing the revised service is very considerable. Attention should, however, be drawn to the desirability of treating figures based on a hypothetical case with caution, and to the fact that while the substitution of an interval service for an irregular one does, as a rule, enable a greater proportion of effective time to be arranged, the extent of this depends to some extent upon the relation which the journey time of the trains bears to the length of the intervals between the trains, which, in the case we have examined, has turned out to be favourable. It is, however, clear that in this type of case the advantages of interval services, from the point of view of operating economy and apart altogether from their convenience to the travelling public, are such that the possibility of introducing them should be explored wherever the density of the traffic is sufficient to indicate there is any chance of doing this successfully.

CHAPTER VIII

FREIGHT TRAIN WORKING

IN Chapter II attention was directed to the effect of the varying speeds of the different types of train on line occupation, and illustrations were given of the effect on line occupation of raising the speed of the slowest class of train; i.e., the slow freight train. Attention was then drawn to the fact that the effect of the higher speed would, at any rate, until a fresh type of locomotive was introduced, inevitably result in a smaller load and thereby lead to an increase in the number of trains. This in turn might increase the demand upon the line occupation and to this extent counteract the advantage gained. The question is of sufficient importance to warrant examination in further detail, especially in view of the recent tendency in other parts of the world to fit all freight rolling stock with continuous brakes to enable an increase of speed to be obtained, and it will be convenient to examine it at this stage.

The loss in load which will accompany any given increase of speed will naturally vary according to the design of the locomotive under consideration. From an examination of a large number of practical examples of the loads quoted for British freight locomotives, we find, that if exceptional cases in which the load is governed by the capacity either to start or to stop the load on an exceptionally severe gradient are ignored, an increase in speed from twenty to twenty-five miles per hour generally necessitates an approximate reduction in the load of about 10 per cent, while an increase from twenty to thirty miles per hour

necessitates a reduction of approximately $33\frac{1}{3}$ per cent. It will, therefore, be seen that the form necessitates rather more than one additional train for each nine at present run, while an increase from twenty to thirty miles per hour necessitates rather more than one additional train for each three trains at present run. An examination of the position on the lines indicated in Chapter II will demonstrate that, considered solely in its effect upon the trains immediately concerned, the higher speed increases the line capacity, even after an allowance has been made for the consequent additional trains. To this must be added the additional advantage of the higher speed more nearly approaching the speeds at which the passenger trains which normally use the same lines run.

Where line occupation is of importance, therefore, there appears to be an overwhelming case for the higher speed. On many lines, however, line occupation is not by any means the most important factor. The additional trains will, as a rule, necessitate the employment of additional locomotives and train crews, and it is desirable, therefore, to examine the position from this point of view. It is generally recognized that the effective use of engine power can best be expressed by the number of ton miles obtained per engine hour. Using the results obtained from the examination of a large number of practical examples as quoted above, we can set out the position in the following simple equations:

If X = the load at 20 miles per hour, then
$20X$ = ton miles per engine hour at 20 m.p h.,
$25(X - 1/10X)$ = do. do. 25 do., and
$30(X - \frac{1}{3}X)$ = do. do. 30 do

If we apply this test to three types of locomotives, the loads of which at twenty miles per hour are 1,000 tons, 500 tons, and 300 tons respectively, which may be said, roughly, to represent typical types of engines used on normal lines, and apply these to the equations quoted above, we get the following results:

Let X = 1,000 tons

Then ton miles	per	engine	hour	at	20 m.p.h. = 20,000
,,	,,	,,	,,		25 m.p.h. = 22,500
,,	,,	,,	,,		30 m.p.h. = 20,000

Let X = 500 tons

Then ton miles	per	engine	hour	at	20 m.p.h. = 10,000
,,	,,	,,	,,		25 m.p.h. = 11,250
,,	,	,	,,		30 m.p h = 10,000

Let X = 300 tons

Then ton miles	per	engine	hour	at	20 m.p.h. = 6,000
,	,,	,,	,,		25 m.p.h. = 6,750
,,	,,	,,	,,		30 m.p.h. = 6,000

It will be noticed that in each case the theoretical results at 20 and 30 m.p.h. respectively are equal, and that from the point of view of hauling efficiency, the 25 m.p.h. speed is the best. If a higher speed than this is considered to be a desirable standard, the general design of British freight locomotives would apparently require to be reviewed. Even under present conditions in this respect, however, the position indicated above must be qualified by other considerations, because the advantage of the smaller load is not confined to the direct increase of speed. It can, for example, be started and controlled much more easily than the larger one, and a further gain on the journey made as a result of the increased ease of handling thereby obtained. The heavier the occupation of the line by trains of varying speeds, the greater this gain becomes.

A practical example of this has recently been within the notice of the writer, in which a rise in the speed of freight trains comparable with the ones under discussion, though accompanied by a considerably larger percentage reduction of load than was really necessary from the point of view of engine capacity, not only increased the line capacity, but at the same time increased the efficiency of the freight engine working as measured in actual ton miles per engine hour. Moreover, advantages are reaped in other directions. The smaller load takes less time to accumulate, thus reducing the time spent in the marshalling yard, which saving of time, added to that saved on the journey, will

improve the transit, and often result in quicker release of a fair proportion of the wagons concerned. It will further tend to reduce delays on the journey, since the faster and more easily handled train can run in front of a more important train with a less margin than a slower one, which again will tend to a better actual result expressed in ton miles per train engine hour than the theoretical result quoted above.

This question of delays raises another question of sufficient interest to be worth some further consideration.

The careful attention which has been paid to the booking and working of freight trains over a number of years—and in this connection it must me remembered that it is the normal practice by one means or another to examine the running of every freight train on each day it runs, in addition to frequent general examinations of groups of trains—has apparently been insufficient to secure a standard of punctual running which approaches anything like the standard for even the less important passenger trains. Even after every allowance has been made for the facts that passenger trains must as a rule have preference, so that anything which may cause delay to them is almost certain to react adversely upon one or more freight trains, and that the task is a more difficult one with freight trains, because the variations of traffic make it necessary to adjust the service from day to day, the results are somewhat disappointing. An appreciation of the real causes of the delays is undoubtedly the first step towards their removal. It will be realised that the immediate cause of most delays that occur is that the signals are against the train owing to a previous train not having cleared the headway distance in advance, or the train having to be shunted for a more important train to pass. This information is, however, of little value. The trains were presumably carefully booked in such a way that this would not occur, and it is not until we have tracked down what in the first instance caused the trains so to depart from the arrangements planned for them that we have found the real cause of the unsatisfactory working.

It will be remembered that when discussing Diagram 4 attention was directed to the way in which a comparatively small delay reacted upon a succession of other trains, so that a small original delay might lead to a total cumulative delay of a much greater period. The effect of delays is indeed so far-reaching and the task of making an analysis so heavy that it cannot be undertaken lightly. Unless such data is already available as a result of the diagram system of control record being in use, the compilation of a diagram on the lines of Diagram 4 from the guards' journals and signal box or other records is a useful preliminary step. The value of such a record, both as a method of discovering the comparatively minor causes of individual delays, and also the major causes of large numbers of delays, is so considerable that it is well worth the labour involved, and an attempt will now be made to describe the process of preparing the data in a form which the writer has found to be convenient.

The result of an analysis into the root causes of freight train delays is both useful and interesting, but its preparation involves much careful and patient work on the part of the compiler. The first part of the process needs little description. It consists of tracking down to its original cause the reason for the delay to the particular train under consideration. The guard's journal or control record shows that train "A" is delayed ten minutes at signal-box "B" and an inquiry from the latter elicits the fact that this was due to train "C" occupying the section ahead. Why was train "C" there? Further inquiry brings to light the fact that train "C" was running 15 minutes late because it had had a twenty minutes' late start from "D," a junction in rear, waiting a connection. The connecting train was late because an unexpected failure of the water supply at "W" had caused it to have a late start of thirty minutes. The real cause, then, of the delay to train "A," was the failure of the water supply at "W," a place which train "A" may not have been within a hundred miles of. Though perhaps a little unusual, this is by no means an exaggerated case,

the first cause frequently being many times removed from the direct one. Without a record of the train working in diagram form, the time taken to answer questions of this type for a whole day's trains would be such as to considerably reduce the value of the resulting data.

As inquiry into the working of the individual trains proceeds, the results are entered on suitable forms, from which a summary may be compiled.

There are so many different causes of freight-train delays that it is difficult to avoid the summary becoming unwieldy. A sub-division under six main heads on the lines of the summary given below is probably as convenient a form in which to present the final result of the inquiry as can be found. The results shown in the statement on page 93, though based on a number of actual cases, must not be regarded as necessarily typical of British railways as a whole, or of any individual system, because so far as the writer knows, similar investigations have not been made at all widely, or, if so, the results are not readily available.

It is advantageous to separate the working of the pick-up trains from that of the remaining trains, as the former are liable to weight the latter unduly in certain respects. The separation of the indirect delay, i.e., that due to the reaction of initial delay to one train upon following ones, from the direct delay, is also desirable, since the removal of the latter will automatically remove the former.

In examining the headings under which the delays have been divided, it may be objected that such items as unbooked stops for cattle and urgent traffics, and other time which has been deliberately incurred as a result of a decision by some responsible person that the needs of traffic necessitated it, should not be included under the heading of delay. There is something to be said for this point of view, but, on the other hand, it is desirable to know to what extent such causes as this have

ANALYSIS OF CAUSES OF DELAY TO FREIGHT TRAINS RUNNING BETWEEN P. AND K. 22/5/30.

Cause of delay.	Excluding Pick-up trains. Direct.	Excluding Pick-up trains. In-direct.	Pick-up trains only. Direct.	Pick-up trains only. In-direct.	Total Mins.	Per cent. of Total.
	Mins.	Mins.	Mins.	Mins.		
Locomotive Efficiency						
Engine late from shed.	108	90	38	7	243	1 8
Time lost in running	1,131	853	—	—	1,984	14·4
Engine failures.	101	241	--	--	342	2 5
Excess time and unbooked stops for water.	147	106	--	—	253	1 8
Excess loco. duties	87	15	—	—	102	·7
Assisting disabled engines.	65	83	53	61	262	1·8
TOTAL .	1,639	1,388	91	68	3,186	23 05
Track and Equipment.						
Permanent way operations.	321	167	37	—	525	3 8
Temp. speed restrictions.	291	117	47	39	491	3·6
Ballast trains.	178	223	—	—	401	2 9
Signalling equipment failures	48	55	-	—	103	·7
Special stops for p.-way men.	106	20	24	—	150	1 1
TOTAL	944	582	108	39	1,673	12 1
Yard Working.						
Delays to engine en route to yard.	263	117	20	—	400	2 9
Excess time marshalling or attaching load.	323	540	45	80	988	7·1
Waiting urgent traffic.	257	228	---	—	485	3·6
Delayed by yard engines working.	203	186	65	17	501	3·6
Waiting guard.	25	73	—	--	98	·7
Waiting van or equipment.	20	10	26	—	56	·4
TOTAL ..	1,091	1,154	156	127	2,528	18·3

Cause of delay.	Excluding Pick-up trains. Direct.	Excluding Pick-up trains. In-direct.	Pick-up trains only. Direct.	Pick-up trains only. In-direct.	Total Mins.	Per cent. of Total.
	Mins	Mins.	Mins.	Mins.		
Main Line Working.						
Unbooked stops for cattle and urgent traffics.	1,513	505	—	—	2,018	14·6
Excess time attaching or detaching en route.	17	73	139	256	815	5·9
Picking up or setting down relief-men.	243	160	57	43	503	3·7
Passenger train waiting connections.	102	87	63	55	307	2 2
Freight train waiting connections.	274	195	43	7	519	3·7
Trains running before time.	187	50	38	32	316	2·3
TOTAL	2,366	1,070	640	393	4,473	32 4
Accidents, etc.						
Stop and examine signal sent.	25	64	—	27	116	·8
Adjusting loads.	59	83	—	16	158	1·2
Detaching defective vehicles or loads.	87	190	—	73	350	2·5
Derailments	175	286	—	175	636	4·6
Trains divided.	67	154	—	67	288	2·1
TOTAL .	413	777	--	358	1,548	11·2
Miscellaneous.						
Swing bridges open.	57	65	10	15	147	1·1
Picking up injured man.	10	15	--	—	25	·2
Road vehicles on level crossings.	167	53	—	17	237	1·7
TOTAL .	234	133	10	32	409	3·0
GROSS TOTAL .	6,687	5,113	1,005	1,017	13,822	100

contributed to the late arrivals at destination of freight trains, while the amount of reacting delay is an indication as to whether good judgment has been used in selecting the trains to be directly affected. Moreover, this figure is useful when deciding how far such special arrangements, which are liable to assist one customer at the expense of a number of others, should, as a matter of policy, be made.

It may also be objected that the heading of "Accidents" is unnecessary, the delays attributed to this being allocated under the heading which is eventually found to be the reason for them. For example, if the accident is due to a defect in the permanent way, delays arising from it should be included under the heading of "Track and Equipment," and so on. This view is quite correct, but, as a matter of expediency, a separate heading is of value. To be really useful it is desirable that the analysis of delays should refer to a recent day, and if its completion were held over, pending agreement being reached as to the cause of the various accidents which occur, many weeks' delay may take place. In any case, efforts are invariably made to remove the causes of accidents and so prevent similar ones occurring, so that nothing is really lost by treating them separately for this purpose.

Without much additional trouble, the data obtained of the individual cases can be compiled in such a way as to lend itself very readily to the compilation of other forms of summary, which are not only interesting, but are instructive in so far as they correct any wrongful general impressions which are so liable to be obtained from general observations. For example, it is interesting to sub-divide further the delays according to the number of times they are removed from the original delay, so as to get a fairly clear impression as to how far-reaching the effect of the initial delay is. Similarly, the separation of the delays according to the number of classes of trains in use in lieu of the simpler separation used above between pickups and other classes only, will help to demonstrate how far a higher

classification of train will tend to reduce the delays on its journey, while if the summary is compiled in still further detail to indicate the class of train which has caused the reacting delay, one of the adverse effects of having a number of different classes of freight trains is demonstrated.

The value of an analysis on the lines indicated can be divided into two principal heads. In the first place the very close scrutiny of the working of each individual train which is necessary draws attention to a number of causes of delay which can be removed immediately if appropriate action is taken. To these must be added a number of cases which, though not lending themselves to immediate correction, indicate a simple line of inquiry which will have the desired effect. These advantages alone are sufficient to repay the necessary effort to compile such data, and the extent to which they are apparent from the initial analysis of a particular section of line may be taken as an indication as to how frequently it may be desirable to repeat such an analysis from this point of view.

The second use of the analysis, namely, to give the correct proportionate view of the causes which contribute to delays to freight trains, is probably much more valuable as indicating the general lines on which the problem of removing the delays should be attacked. It can, for example, hardly be expected that the standard of maintenance of the engines used for freight, as distinct from passenger work, should be such that no time would be lost from the causes included under the heading of locomotive efficiency. The price of doing so would almost certainly be prohibitive. It is, however, important that the extent of loss from the standard which has been adopted as the economical one should be realised so that a proper balance may be maintained between the two considerations. Similar considerations, though to a less extent, apply to the causes included under the heading of track and equipment, the principal

difference being that in most cases the permanent way is in common use by passenger and freight trains, and the necessary standard for passenger trains must be maintained. Under this heading, it is especially desirable to know whether any reduced cost of executing extensive permanent-way operations during such times that a considerable number of trains are running is not more than offset by the additional costs to those trains as a result.

Passing to the operating side, an indication is given of the most promising directions for inquiries with a view to repairing any defects and of the effect of deliberate departures from the booked working for special reasons. Perhaps the most interesting of the items under the two heads of yard and main-line working respectively, is that of the effect of trains running before time and so interfering with other trains which require possession of the line at the time the former have taken possession of it. There is clearly no objection to a train which, for one reason or another, has completed its work in less time than is booked —which presumably represents the time which is normally necessary—making progress towards its destination so long as the gain to that train is not more than offset by loss to other trains which it may displace. There seems, therefore, to be little or no justification for a general ruling that freight trains must not, when opportunities allow, run before their booked times, but it does seem to be generally desirable to ensure that they shall not do so at the expense of other trains suffering an equivalent or more than equivalent loss to the gain made by the former. The difficulty of anticipating the extent to which one train is liable to react upon another is, however, so great that it is very difficult to lay down a sound general rule to apply in such cases. On a line where the density is heavy, and where a high standard of punctuality has already been reached, it is probably sound to insist upon trains not running before time as a general rule. In the more normal cases, however, in which the standard of freight train

punctuality is considerably lower, such a rule would lead to a good deal of additional delay, both directly and indirectly, and any attempt to prevent interruption to booked paths by holding trains which are before time, for their proper time, is just as likely to cause delay as to avoid it.

CHAPTER IX

FREIGHT TRAIN SERVICES

HAVING dealt with the general questions relating to the loads and speeds of freight trains, the relations between them, and a method of tracing out the original causes which together interfere with the efficient working of such trains as may be arranged with a view to their removal, we must now consider what is in reality a quite separate question, viz., the arrangement of train services for goods traffic. There may, in the past, have been a tendency to emphasise the importance of a high standard of train-running in such matters as punctuality, train-load, etc., to the neglect of the equally, if not more, important consideration of efficient train services, and in some quarters, at any rate, it would almost appear as though the difference between these two considerations has not been realised. Good train loads can frequently be obtained by giving bad services, and in this connection the writer would again emphasise a point which has already been touched upon more than once that, as a rule, bad services are not only bad from the point of view of the trader, but are bad when considered solely from the point of view of operating cost.

It is difficult to find a word which expresses the manner in which British goods train services have developed. To say that they have grown up to meet the needs of expanding traffics is to tell only a small portion of the story. There has been, and still is, an almost constant succession of building up and partial pulling down again

and rebuilding to a different pattern in an attempt to meet the ever-changing amounts and directions in which traffic is offered for conveyance. It is as though one were trying to construct a complete jigsaw picture with the shapes of the different pieces constantly changing and with no hope of their ever ceasing to do so.

Minor alterations are made as a result of the vigilance of the yardmasters, stationmasters, controllers, freight-train and time-table clerks, inspectors, and the outside staffs, who are constantly watching for the opportunities to make improvements. A smaller proportion are the result of attention being drawn to cases of delay by the traders interested. In both cases the inquiry made in connection with one case may bring to light information which suggests further improvements. It is inevitable, however, that the cumulative effect of the frequent changes and the conditions under which they are made should be to provide scope for further improvements which cannot readily be appreciated during the processes of carrying out the individual changes. This, together with the constant fluctuations in the flow of the different kinds of goods traffic, which appear to change with greater frequency and in greater degree in recent times, make it desirable that the services themselves shall frequently be reviewed as a whole. It is, therefore, proposed to set out one or two typical examples of the way in which such review can be conducted.

It is clearly essential that the operation of reviewing a train service in an area shall be carried out by someone who has a thorough knowledge of the railway geography of the area under consideration. In order, therefore, to simplify the setting out of the problems at present under consideration, use will be made of Diagram 1. The data required consist of the numbers of wagons passing between the different points on the lines and a knowledge of the train speeds and loads which are desirable for the different sections of the line concerned. The period which it may be necessary to take in order to give a reasonably accurate

picture of the traffic passing will vary a little under different circumstances. A week is usually sufficient, but the analysis should show separate particulars for Monday to Friday, and Saturday respectively, owing to the shorter working day on Saturday affecting the total amount of traffic passing.

There is a good deal to be said for a fairly regular compilation three or four times a year, so that the conditions for the different seasons of the year may be compared with each other, and with similar particulars for preceding years.

Theoretically, it would appear to be desirable to compile the necessary particulars for the whole of a company, or at any rate a large area, at the same time, and consider the service as a whole. In practice, however, the resultant data are inclined to be so unwieldy that the maximum benefit is not obtained. It is usually better, therefore, to deal at one time with two or three yards where the working is closely interwoven.

The form in which it is desirable to present the data varies a little with the type of yard. If the yard at "A" (Diagram 1), being a purely terminal one, is taken, the destinations of the different wagons which leave "A" will give the necessary information. If the yard at "P" is under consideration, not only the destinations, but the originating points, should be obtained, the Up and Down yards being treated as separate units. In the case of "C," where the traffic flows into a common point for distribution in all directions, which will probably have led to a yard being constructed which serves in common both Up and Down directions to and from the different branches converging at it, a similar form is used, but without the division between Up and Down directions.

At terminal points particulars can be obtained from the records of wagons loaded, but where wagons already in transit are concerned, a special record is usually required, and in this case it is convenient to take a record at the marshalling yard itself. A convenient form in which the resultant particulars can be summarised faces page 100,

the yard at "C" previously referred to being taken as the example for detailed discussion.

It will be noticed that the top and side headings of the statement are identical, so that one may see at a glance the average number of wagons which have passed through the "C" yard to and from the different places or groups of places. For convenience of setting out, the full headings have only been given at the side, abbreviated headings being used at the tops of the columns. The thicker lines are used to group the smaller divisions according to the last stage of the journey before reaching "C" yard. For example, the first three headings may be described as the "B" group since the traffic from station "A," stations between "A" and "B," and stations beyond "B" in the direction of "H," will all pass "B" on its way to "C." The exception to this is what we may call the "C" group, which includes traffic to or from "C" from or to wayside stations served by "C" on the branches radiating immediately from it. In some cases where the number of subdivisions is large, it is an advantage to compile separate group totals, and in others to divide the main groups into sub-groups according to the traffic passing through two or more important junctions farther removed from the centre under consideration than the last junction. The reader should have no difficulty in following the principles on which the statement is compiled if careful reference is made to Diagram 1. The object of grouping the heads in the manner described will be apparent when we begin to consider the data presented by it.

We are now in a position to see how far the traffic available offers opportunities to improve the services of the traffic at present passing through "C." Considering first the sub-division of the traffic under the individual headings, and dealing for the moment with the normal weekdays, we notice that from "A" there is a daily average of 39 wagons to "E" and stations served by "E," and 38 wagons to "F" and stations served by "F." Unless, therefore, a load of this size is not accepted as being

sufficient to warrant the running of a through train, it would appear that such trains should be arranged from "A" to these two points. Similarly, there would appear to be a case for a through train for the 51 wagons from station "B" to "F" and a further examination of the statement on these lines, taking a minimum of 35 wagons as sufficient to warrant through train working, will indicate a number of other possibilities in this direction. It may be, of course, that some through trains are already running between such points, but if this is so, it would appear that additional through trains are desirable since the statement only includes traffic which has actually been staged through "C" yard.

Having disposed of the individual centres, the possibilities arising from the group centres should then be examined, for example, neither "A" nor "B" centre has sufficient wagons to warrant a through train to "N" with traffic for "N" and beyond, but if the traffic from "A" and "B" for this centre is combined at "B," an average of 39 wagons a day would be available. Whether this particular step is desirable, however, requires further consideration. If the traffic from the "C" group is added, it will be seen that there is a total of 59 wagons per day from "C" to "N" and beyond, and it may be that, on balance of the whole of the circumstances at the different points in the area, it is better to make "C" the collecting point for this particular destination. As a general rule, however, it is better to make the through train for the longest possible distance, and in this case the train starting at "B" could, if desirable, call at "C" and pick up the section of "N" traffic arising at the "C" group stations. The statement will also draw attention to cases in which yards which already have services past "C" are staging a certain number of wagons through "C." Under certain circumstances this may be legitimate, but the practice should be kept under careful control.

When the possibilities the traffic offers have thus been discovered, the necessary revision to the train timings, engine working, guards' working, and other similar ques-

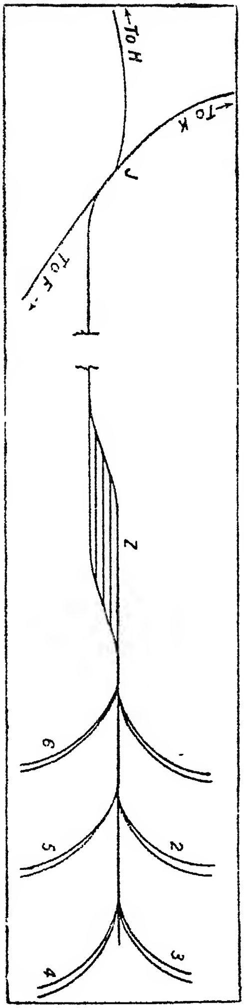

Diagram 13.

tions must be arranged, after which the improved services can be brought into operation. A similar process must, of course, be gone through in connection with the opportunities the lighter traffic offering on Saturday gives. The advantage is not confined to the gain in transit time of such traffic as has been directed past "C" yard. The relief to that yard should, sooner or later, reduce the working costs there, while much of the remaining traffic should benefit as a result of its being dealt with earlier. Against this must be set the possible risk of worsening the service for a proportion of traffic which must continue to pass through "C" yard, because the reduced number of wagons entering the yard reduces the possibilities for services from there.

We have just discussed a case in which the improvement of the train services provided incidental relief to marshalling yard accommodation. It frequently happens that the need for the latter, or the alternative of incurring the expense of providing increased accommodation, is the direct reason for considering the possibility of revision.

Let us suppose that a short distance outside the station "J" (Diagram 1) in the direction of "F" there is a short spur line connecting an area which, owing to certain natural advantages, has been developed for special industrial purposes (see Diagram 13). The spur line is regarded and worked as a siding under the control of the "J" yard. Towards the end of the spur there is a small group of four sidings, "Z," beyond which are leads into six different works, 1 to 6, all of which are developing at a fairly rapid rate. The nature of the business is such that on the whole the receipt and dispatch of wagons are spread pretty evenly over the working day. Originally, traffic for these works was worked from the marshalling yard at "J" to the group of four sidings previously referred to, and, having been sorted there, delivered to the appropriate works, the outward traffic being lifted from the works sidings and worked to "J" yard to be marshalled with the other traffic dealt with at that point. The development in this area was not contemplated when the marshalling yard at "J" was

constructed, and the traffic to be dealt with there was as much as could be handled economically even before it took place. To make matters worse, with the expansion of the works and consequently the traffic, the pressure for earlier delivery of some of the inward traffic has necessitated a certain amount of preliminary sorting at "J" before forwarding to the group of sidings at "Z." The not unnatural result of this state of affairs is that an application has been made for an extension of the small group of sidings at "Z" to enable the whole of the local marshalling to be done expeditiously there, and for an extension of the facilities at "J" to meet the requirements of the new and additional traffic. In the meantime, the congestion which naturally follows the attempt to deal at "J" with traffic considerably beyond the capacity of the accommodation there has not only increased the cost per unit of traffic handled, but is leading to serious delays, which in turn are handicapping the development of the industries, the present traffic of which has caused the difficulty.

Let us assume that the possibility of relieving the pressure at "J," by diverting traffic staged to it from other centres, has been explored, and that everything possible in this direction has been done without easing the difficulty sufficiently to meet the case under consideration. The first step in this, as indeed in all similar problems, is to discover the extent and destinations of the traffic concerned. An inquiry into the present state of affairs brings to light the fact that the traffic arising in the "Z" area amounts approximately to 250 wagons per day, and that these are available for lifting to "J" in loads of 40 wagons at intervals of about four hours, the normal arrangement being that an engine works a load of inward traffic from "J" to "Z," completes the sorting of and delivers its load, and lifts a load of outward traffic back to "J" in about this time. A statement, similar in principle to the one discussed earlier in this chapter, but much simpler to meet the needs of the simpler case, is now required. In view of the amount of traffic involved, a statement—for a period sufficiently long to be typical—of traffic

for individual destinations grouped according to stations served direct by trains starting from "J," and other stations served *via* "H," "K," and "F" respectively, would probably be sufficient. This information will readily be available from the records of forwardings which will be kept. It is not necessary to reproduce the details of such a statement in the case under consideration, it being sufficient to say that it showed that the 250 wagons per day were approximately divided as follows:

To	stations	*via*	K	...	...	148	per	day.
,,	,,	,,	H	...	...	80	,,	,,
,,	,,	,,	F	...	...	16	,,	,,
,,	,,	,,	J	...	...	6	,,	,,

With this information before us, the possibilities in the way of relieving "J" at once begin to emerge, but, before we proceed further, it is desirable to know what is happening to the traffic for "K" and "H" directions respectively, at "J." Inquiry at the latter point elicits the fact that, apart from the separation into the two directions, which is essential, the pressure upon the accommodation there prevents any opportunity being realised of doing more than passing on the traffic received to "K" and "H" respectively.

The traffic between "Z" and "K" is approximately equivalent to three loads per day, and that between "Z" and "H" to two loads per day. If, therefore, it is possible to arrange direct trains from "Z" to "H" and "K" respectively, a solution to the problem, which at once improves the service for the outward traffic and provides considerable relief at "J," is provided. The circumstances in this case afford an excellent example of the advantages of co-operation between the trader and the railway company to their mutual benefit. It will be clear that if the traders concerned in this traffic could arrange to fit in their loading—or, alternatively, their arrangements for placing the outward wagons in the exchange sidings—with a timetable of alternate trains, at mutually convenient times, to

"H" and "K" respectively, at suitable intervals throughout the working day, starting and finishing with a train for the "K" direction, so as to cater for the additional load to that point, with one train per day for traffic which must continue to go to "J" (i.e., that for the "F" direction and other stations in the vicinity of "J"), any further loss of time in marshalling to enable through services to be run would be avoided.

In these days, most large traders would be willing to co-operate in such a way, and, except in exceptional cases, it is probable that any difficulties they had might be such as could be overcome with a slightly altered organisation. In so far as they could not, arrangements would have to be made for the separation of the remaining traffics to "H" and "K" respectively to be done in the small group of sidings at "Z." It may be, for example, that the remnant of traffic which had to go to "J" was the difficulty, in which case it might be separated from the other traffic before the through loads were dispatched, and accumulated in the sidings at "Z" for a trip to "J" at the most convenient time. In many cases it would probably be found that the firms concerned could go even further and, if given the forward services from "H" and "K" respectively, arrange their traffic in such a way that that for the services leaving "H" and "K" earlier than the remainder would be made available for the earlier trips from "Z." The result of such an arrangement may be summed up as follows: The yards at "H" and "K" would have no additional work imposed upon them because they are already dealing with the traffic. The yard at "J" would be relieved of over 90 per cent of the traffic from "Z," and the relief would enable the other traffics which continued to be dealt with at "J" to be dealt with more conveniently. The traffic directly concerned would receive a greatly improved service to the advantage of both trader and the railway company, whilst the need for capital expenditure on additional siding accommodation at "Z" and "J" would be obviated.

The traffic in the reverse direction has still to be con-

sidered. If it is coming from approximately the same directions as the outward traffic is going, the obvious way would be for "H" and "K" respectively to make up train loads for "Z" marshalled for the six sidings. Before any conclusion could be come to, however, a similar analysis of the traffic in the reverse direction would be necessary. If this indicated that similar advantages could be gained, the total relief at "J" would be very considerable, but even if this were not the case, and it was necessary for "J" to continue to receive the inward traffic, and for it to be dealt with as previously, the relief already afforded would ease the difficulty of doing this, whilst the balance for train working purposes between "J," "H" and "K" respectively would not be upset because, however unbalanced the traffic for "Z" was the conditions in this respect had not altered. This case is typical of many that can be found in common practice. The principles illustrated by it are not affected by the fact that "Z" is a centre serving a group of private sidings only, nor that it is in close proximity to "J" and the distances between "J" and "K" and "J" and "H" respectively are not very great.

Other somewhat similar illustrations might be given, but the two quoted are probably sufficient to illustrate both the importance of such investigations and a satisfactory method of conducting them. They may also have demonstrated how very far-reaching the effect of poor services may be, not only from the point of view of the transit of the traffic and the user of the vehicles, but in their effect upon the provision of accommodation and working costs. These are indeed so important that to the direct reward which successful searches for improved services may bring must be added many indirect advantages which, being in many cases accumulative in their effects, may frequently equal, or even outbalance, the direct advantages.

CHAPTER X

LIGHT SHUNTING ENGINES

THERE is still considerable difference of opinion among responsible railway officials as to the scope which exists for the employment of shunting engines of light type, such as the "Sentinel" shunting engine. Until comparatively recently, their use on British railways was, apart from quite exceptional cases, unknown, and the view was freely expressed that any advantages they might have over the shunting engine of the normal railway locomotive type were far more than outbalanced by their limitations. To some extent this was undoubtedly due to the convenience of reserving the lighter work for engines of the normal railway locomotive type which had been displaced for main line work by engines of later type and bigger hauling capacity, but which still possessed some years of useful life. The stringent restrictions upon engine building which financial and other considerations have imposed during recent years has modified this influence. In some degree also the loss of the advantages of standardisation which the introduction of a unit of a new type involved tended to create a prejudice against it, though clearly it should not have done so had standardisation been regarded, as it should, as the means to an end and not an end in itself.

Gradually, however, as practical experiments were made, the light type has been found to be increasingly valuable, and the tide is rapidly turning in its favour as its value becomes more widely recognised. It must, moreover, be remembered that the light type is in its earliest stages of

development, and that its comparative simplicity of design and lower cost per unit combine to encourage experiment in search of improved design. The progress which has been made in this direction during the last few years makes it necessary to write with considerable caution on this aspect of the question, but, at its present state of development, it may be stated that its use as substitute for the normal type of railway locomotive on freight work can conveniently be divided under three heads:

(*a*) The simple substitution of engines constantly employed on shunting work.
(*b*) For shunting purposes in lieu of the engines of trains of the pick-up and similar type, chiefly at wayside stations.
(*c*) The complete substitution of the normal type of locomotive on branches where traffic is such that the total load is small.

Before discussing the possibilities under these three heads, reference should be made to the comparative costs of working the different types of engines. The light unit type has hardly been in use sufficiently long for a very definite comparison to be made. The principal heads under which the comparative costs must be calculated are, of course, Interest on Capital, Maintenance and Renewal, and Cost of Working, the latter being divided into manning cost, and cost of fuel, oil, and other stores. If the comparison of capital cost be made on new units in each case, the light unit undoubtedly scores, but the comparison must more frequently be made between the new light unit and the book value less scrap value of the heavy unit which has become obsolete for main line purposes. The cost of renewal is that on which there is most doubt in the absence of the necessary length of experience of working to prove how long the useful life of the light unit is. The reduction of the engine crew from two to one reduces the manning cost in almost equal proportions, while the reduction in coal, etc., consumption is considerably greater.

In considering all three costs, moreover, the advantage the light unit gains by its greater availability in service

must be remembered. The saving of time in preparing, stabling, and in less frequent and shorter periods of intermediate "loco duty" time, enables the cost of the light type to be divided over a greater number of effective working hours. In regarding the comparative cost of the light type as approximately half that of the older type, therefore—which is accepted in many quarters as a reasonable approximation—it is at least possible that the comparison is unduly weighted in favour of the latter. The actual cost in the case of either type will vary according to the nature of the work, the method of calculation, and so on, but for our purposes we can take as a rough guide the fact that if the lighter type of engine can perform the work under consideration in the same time as the heavier type, the cost will be reduced by half and that advantage will be maintained up to the stage where the light unit will occupy twice as long as the heavier one, at which point the costs will become equal, though we may still be gaining in other directions by employing the lighter unit.

In the first case mentioned, namely, the simple substitution of engines constantly employed on shunting work, the merits of the case for substitution depend entirely upon the capacity of the lighter type engine to perform the work efficiently in an amount of time either equal to, or up to, but not greater than, twice the time occupied by the heavier one. Experience has proved that the present type of light unit is not suitable for marshalling yard work proper. The engine itself is not sufficiently heavy to give the quick control that is desirable to shunt at the speed necessary at large marshalling yards with a fairly constant succession of traffic. Keeping in mind, however, the comparative costs of the two types, there is probably a case for experimental use for purely marshalling purposes at small marshalling yards where the shunting work is only intermittent, and the rate of shunting less important. For shunting work at goods stations of considerable size, or on spur lines serving private sidings, where circumstances make it necessary to separate for delivery and/or collect for forwarding to the

marshalling yard proper, groups of up to, say, 15 or 20 wagons, it is, if anything, superior to the more normal type of locomotive, quite apart from its reduced cost of working. The ease of handling, the less frequent interruptions for water supply and other locomotive duties, and its general handiness, all tell in its favour. The same advantages apply for many types of dock shunting work.

It is, however, in connection with the type of work mentioned under the second heading that in the writer's view there is the greatest scope for its development. The problem of providing a satisfactory service for wayside stations is a very old and difficult one, which until the advent of the light type of shunting engine appeared to be incapable of satisfactory solution, except at prohibitive cost. The station that is fortunate enough to be near the starting point of the pick-up train can be given a reasonable morning delivery, but, by the time the pick-up has served a number of stations along the branch, it is frequently noon or later before the first daily service arrives. In the reverse direction, if the wagons from the wayside stations are to reach the marshalling centre in time to connect with that night's outward trains, the train must commence its journey so early that the earlier stations served by it must have their goods ready loaded by the early afternoon, and thus give little opportunity for forward transit on the day the loading of the goods commences. The inconvenience is aggravated by the fact that the agricultural produce which forms the bulk of the roadside station traffic has frequently to be carted for a considerable distance to the station, and involves a number of journeys before a wagon-load can be completed. The development of the use of road motor vehicles has made the position an even more unsatisfactory one from the railway point of view.

Again, the pick-up type of train, by its very nature, makes the biggest demand upon the line occupation, the comparatively short distances between stations never giving it an opportunity to run at really satisfactory speeds even though the load is relatively light. At many stations, more-

over, the expense of providing special accommodation in which the remaining train can stand while the station shunting is performed is prohibitive, and the main line must be occupied during the whole of the process. These in turn make it essential there shall be a substantial margin in front of passenger or through freight trains which may be following, thus adding a fair proportion of ineffective time at the stations to the time necessary to perform the shunting there. The endeavour to make some improvement has led to many of the services being wholly or partially duplicated, though it may be doubtful whether the direct revenue from the traffic is sufficient to justify the extra expense. It is on the possibilities attending the use of the "Sentinel" type of shunting engines, with the object of overcoming the disadvantages mentioned, that the view just expressed is founded.

If regard be paid to the features mentioned, it is a little surprising that the opportunities offered by the introduction of light shunting units were not more readily recognised, though this may be attributable, at least to some extent, to the same causes. In the efforts to overcome the difficulties referred to in the absence of light shunting units, much painstaking and efficient work had been performed in the direction of introducing semi-pick-up trains, using what would otherwise be through trains to serve one or two of the more important stations, and, by other similar means, relieving the situation. This, in turn, necessitated rearrangements of the engine and train men's workings, and in many cases resulted in workings which were less economical than those which were possible when a simple pick-up service serving in turn the stations on a branch was considered sufficient. The effect of this has been twofold. On the one hand, the opportunity for introducing the light shunting unit has tended to be obscured, and, on the other, those concerned have hesitated about introducing a new method which will wholly or partially upset the ingenious scheming which has given what has come to be regarded as a reasonably efficient service. It is, however, important

to remember that it is because of this that the savings to be derived from the introduction of the light unit are greater than they otherwise would be. The question may be asked, why, with all these advantages, the light unit has not been substituted for the heavier one on a wholesale scale? A little consideration will, however, make it clear that before the substitution is desirable, it is necessary to discover cases in which it can be done on a sufficiently large scale to enable a heavy unit to be saved for approximately a complete shift, either directly or by rearrangement with engine turns other than those directly affected.

In the simplest type of case—namely, that in which the amount of time spent at stations by a pick-up train is such that double shifting of the train engine is necessary, and the employment of a light unit at some or all of the stations will relieve the train engine of sufficient of its shunting work to enable the train work to be completed within a single shift—it is hardly necessary to resort to a diagram. The facts of the case affected by the alteration can be set out clearly in simple figures. In most cases, however, the relief the light unit gives must be spread over more than one train, the best opportunities frequently occurring at the larger stations near some centre. Hence, it is difficult to appreciate all the favourable opportunities for introducing light type shunting engines to relieve train engines of their shunting work, unless it is possible to present the facts in some form which will show clearly, not only the amount of shunting time at present occupied at each station, but the total time spent there, and the effect the relieving of the train of all or a portion of its shunting work will have upon it.

If diagrams of the type of Diagram 4 are already available, and the working under consideration is confined to points already shown on that diagram, it is hardly necessary to prepare a special one; but if, as often will be the case, two or more diagrams of the type referred to are involved, or no diagram at all is available, the type of

diagram shown in Diagram 14 provides a more convenient method of presenting the information for the whole of the lines concerned. The very simple illustration given on Diagram 14 does not actually represent a case where two lines are concerned, but will be sufficient to illustrate the lines on which the more complicated case should be constructed. Diagram 14 illustrates the consideration of the working at the intermediate stations between "F" and "G" on Diagram 1, with a view to exploring the possibility of introducing a light shunting unit. There are three stations between these points, which for convenience have been named 1, 2 and 3 respectively. No. 1 is a small wayside station. The two others are of considerable size, and the traffic of such a character that a good deal of shunting is necessary, and that at Station 3 of such a volume that more than one service a day is required to enable it to be dealt with in the accommodation provided. Having decided upon the form of diagram, which will be apparent from an examination of the one given, the first step is to plot out upon it the working of the trains under consideration, distinguishing either by means of colour or in some other method the different ways in which the time is occupied, i.e., at stations, shunting or waiting margins respectively, in running, etc. The present working is as follows:

	Arr.	Dep.	Remarks.
	a.m.	a.m.	
Station F		9. 0	
" 1	9.18	9.36	
" 2	9.54	11. 0	Shunts until 10.36 and waits passing of No. 14.
		p.m.	
Station 3	11.18	12.40	Shunts until 12.15 and waits for passing of No. 20.
	p.m.		
" G	1.15		
			Engine dismissed 1.50.
			Engine in yard 2.20.
" G		2.42	
" 3	3.12	4.12	
" F	4.42		

	Arr. p.m.	Dep. p.m.	Remarks.
Station F		5. 0	Engine and van.
" 3	5.30	6.25	
" 2	6.40	8.10	Shunts until 7.50 and waits for passing of No. 40.
" 1	8.20	8.32	
" F	9. 0		

For engine working and train men's working purposes, these trains have been combined and worked by double-shifting an engine and using two shifts of men, who change on the arrival at Station "F" of the 2.42 p.m. train from "G."

When this information has been set out on Diagram 14, we can see at a glance what opportunities there are for relieving the train engine of shunting work, and form a general impression of the effect this will have on the working of the train and traffic, which can be confirmed by plotting the proposed working upon the same diagram. It is, perhaps, hardly necessary to set out the proposed working in the same detail as the form set out above, but an explanation of the work to be allotted to the light unit may be desirable so that the diagram may readily be followed. The light unit prepares the yard at Station 2 in such a way that the train engine can with one or two shunting movements put the arriving traffic in position for delivery to be taken. It then proceeds to Station 3, and, having again prepared the yard, receives the traffic on the arrival of the train and places it for delivery as necessary. The light unit returns to Station 2, makes certain changes that may be desirable there during the quiet time about the dinner hour, and returns to Station 3 in time to deal with the traffic which the train has delivered on its return trip from "G." It remains at Station 3 sufficiently long to prepare the majority of the traffic for lifting by the last trip from Station 3 to Station "F," then proceeds to Station 2 and prepares that station's traffic for the same trip, afterwards generally adjusting the positions of the remaining wagons in the yard as may be desirable. It will be noticed that more time is booked at both stations, but particularly at

Station 3, than is really necessary, and this is referred to later. The employment of a light type of shunting engine at Stations 2 and 3 respectively has so relieved the train engine that the work which previously took two shifts can be completed in one shift.

This in itself would appear to justify the employment of the light type of shunting engine, though the possibilities have by no means been exhausted. Under the present working, the train engine spends approximately 4.7 hours shunting at Stations 2 and 3, but, on the proposed working as arranged, 6.2 light shunting engine hours are available, to which must be added a portion of the 1.6 hours which are still spent by the train engine at those stations. It will thus be seen that the proposed scheme provides a margin of power which might be regarded as available to meet an increase in traffic. Alternatively, a rearrangement of engine working, in which other trains were also concerned, might enable advantage to be taken of this, if, by relieving the revised train turns of still further shunting, the necessary services could still be given. Ignoring this margin, however, the advantages of the revision as indicated on the diagram may be summarised as follows: The cost of the working is reduced by half the cost of one engine shift by the employment of the lighter type of shunting engine in lieu of the heavy type for one shift. The first delivery of traffic at Station 3 is approximately three-quarters of an hour earlier, and at Station "G" two hours earlier than before, and in turn the midday trip from Station "G" to "F" is approximately two hours earlier. On the other hand, traffic from Stations 3, 2 and 1 reaches "F" three hours earlier in the evening, thus affording opportunities for making earlier connections than would otherwise be the case.

It has been assumed that the light shunting unit can be stationed at Station 2, though it is unlikely there will be an engine shed there. If it should be considered necessary that an engine of this type should be stabled at an engine shed, there would be time for it to travel light from and to

"F" at the respective ends of the working day, and still perform the necessary shunting work, though this would naturally reduce the reserve available for additional work. To get the maximum use out of the light shunting unit, however, it would appear to be desirable to depart somewhat from the specialisation of labour which is followed in normal locomotive practice, and place the light unit under the care of a driver who is capable of taking sole charge of his engine and preparing it for duty at the beginning of each day, on much the same lines as the road motorman using a similar type of engine does, even to the extent of performing light repairs, and thus enable the engine to be stationed at the point which reduces the ineffective time at the beginning and end of the shift to a minimum.

Such a case as that mentioned under our third main heading, namely, the substitution of the normal class of locomotive for trains working on branches where traffic is such that the total load is small, is nothing like so common as the type of case we have just been discussing. Here, again, however, there may be possibilities which have not yet been appreciated. The design of the light shunting engine has by no means reached finality. There are already in use shunting engines of the "Sentinel" type which are more powerful than the smaller types of normal locomotives, and there would appear to be no reason why a considerable increase of power should not be given without sacrificing an undue proportion of the economies the light type of engine gives. The margin between the costs of working the two types is such that where necessary the traffic to be handled might be reduced to within the capacity of the light type of engine by duplicating the service over a portion of the line, and still leave some saving to add to the advantages of the improved service. With suitable gearing, the engine could if desirable be used to haul passenger vehicles of a type suitable for a branch that is likely to provide the right type of freight train, and further advantage thereby be reaped from the substitution.

CHAPTER XI

MINERAL TRAFFIC FOR SHIPMENT

REFERENCE has already been made to one direction in which, by co-operation with the trader, the working of freight traffic can be improved; but there would appear to be the greatest scope of all in connection with the working of traffic on what may be called a wholesale scale, such as that of mineral traffic for shipment. To assist us in considering a typical example of this, it has been assumed that the section of railway illustrated on Diagram 1 included an important coal shipment port at "A," and two coalfields, shaded and lettered "X" and "Y" in the reproduction of this diagram, which appears on page 120 (Diagram 15). The position of three of the collieries only is indicated. These should be ignored for the present, having been inserted for use in connection with Chapter XII. The output from these coalfields is not confined to shipment coal, there being a demand for industrial purposes in those parts of the area which the density of railway lines and trains upon them indicate to be engaged on a large scale in industrial operations of one sort and another, and over the whole area for household purposes. The proportion of output supplied to these various markets will vary, depending upon the many different factors affecting the demand for coal, and the price the consumer is, therefore, willing to pay for it.

Confining our consideration to the shipment portion of the traffic, we will first assume that there is no regulation system of any kind in operation in connection with the

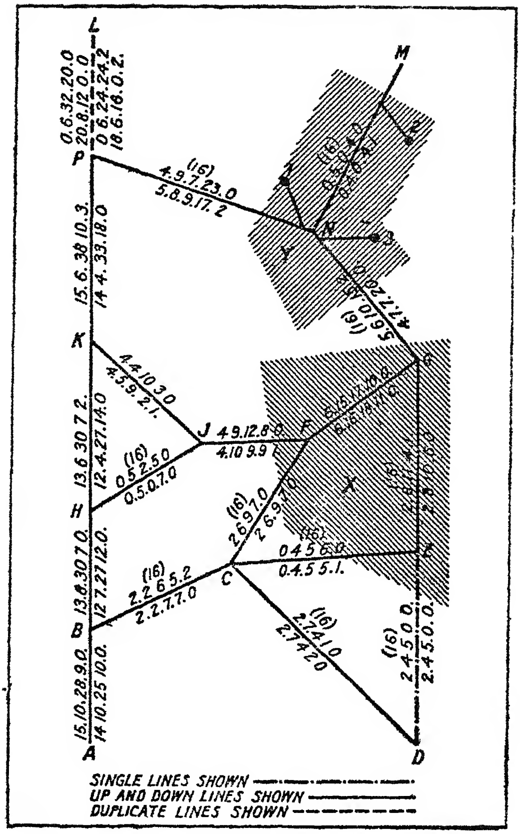

Diagram 15.

mineral traffic shipped through port "A." There would then be two alternatives open to those responsible for the marketing of the output of coal from the collieries. They might, without waiting for any definite shipment orders, dispatch such quantities and qualities of coal as was convenient to them, consigned to themselves or some agent, to port "A," in the hope that orders for this would be forthcoming. Alternatively, they might, before consigning any part of their output to the port, wait until their selling agents reported that orders had been received, and endeavour to time its dispatch so that it would reach the port about the time required for shipment. In practice, they would probably combine these methods, the extent to which the latter was adopted depending upon the current demand for their output.

The advantage to them of the former method would be that it would put them in the position of having quantities of coal of their different qualities on hand at the port, and therefore in a position to accept short notice orders for "spot" coal, for which the shipper might be willing to pay a little more than the then ruling price. Against this, there would be the continued cost of the wagons in which the stocks of coal were stored at the port, and the siding accommodation occupied by them. In order, therefore, that the case against the non-regulation system shall not be overweighted for the purpose of comparing it with that for a regulation system, we will make the comparison on the assumption that the second alternative method, namely, that the coal is only sent to the port after definite orders for shipment have been received, is the practice followed.

Let us consider the case of the shipment of a parcel of, say, 5,000 tons of best steam coal, which the shipper placed with a colliery in area "X" on, say, March 1, for shipment in the s.s. *Koalcarrier* from port "A," which vessel, it is stated, will be ready to receive the coal at that port on March 14. The colliery manager, knowing that coal from his colliery has on occasions taken three or four days to

reach port "A," would probably, unless he were having difficulty in meeting his current orders, add a day to this to make sure, and—if we assume that his output is such that it would take him three or four days to supply the total quantity—would begin almost at once to load and ticket the coal for dispatch. A number of the wagons containing part of the coal towards the order would therefore be placed in the dispatch sidings ready for the railway company to work forward, ticketed for port "A," along with coal for other destinations. The railway representative on the spot, or a visiting representative from some station in the vicinity, when making his periodical visit to the colliery sidings, would take particulars of the traffic, and communicate with the centre responsible for arranging engine power for it to be lifted. In many cases the service would be prearranged on the average requirements of the collieries on that branch, such service being adjusted in either direction according to whether the traffic on a particular day was above or below the normal. In this way the traffic loaded at the colliery would be worked to the nearest marshalling yard, and, except in so far as in certain areas there is sufficient mineral traffic to justify its being dealt with in separate marshalling yards, it would be dealt with in the same way as goods traffic and worked forward along with other freight traffic for the same direction to the next convenient marshalling yard for handling it. (Considering the area "Y," the traffic from the collieries on the "NM" and "PN" branches would probably be worked to "N" and that from the collieries on the "NG" branch to "G," unless the flow of coal from that area in the direction of "NP" made it desirable to concentrate from both directions at "N," even at the cost of extending the distance a portion of the traffic had to be hauled. The traffic arising in the "X" coalfield might be concentrated at "C," though some of it would almost certainly be staged to "E" and "F" before reaching "C.") If everything has gone well, therefore, the traffic should by this means have all reached "A" a day or two before March 14, some of it having been there some

days earlier, and if the ship is available the full order can be shipped without difficulty.

It will, however, be appreciated that if we take the average load in the wagons as 10 tons, 500 wagons would be necessary to carry this cargo. The average length of a 10-ton coal wagon may be taken as seven yards, so that 3,500 yards, or, roughly, two miles, of siding accommodation will be occupied by them. If we say that the first parcel of coal was filled and dispatched on March 4, and the coal dispatched in four 1,250-ton lots on successive days, the total number of wagon days occupied up to March 14 is 4,250, an average of 8.5 wagon days per wagon, so that two miles of sidings would be occupied for 8.5 days. For the purpose of this calculation, it has been assumed that the full 5,000 tons have been shipped on March 14, which is unlikely.

In practice, moreover, it is improbable that the ship would be available to take the coal on that day—March 14. In giving this date to the shipper, the shipowner's representative would be anxious to be on the right side so as to avoid any possibility of the ship losing time waiting cargo, whilst the shipper would be anxious to make sure that his coal was at the port in good time. To any margin that they added for these reasons must be added the effect of delays which are inseparable from sea transit, e.g., delays owing to bad weather, and so on. The position in regard to coal from the "Y" coalfield will be very similar, except that the greater distance may make it appear to be desirable to add a day or so to the transit time.

If we assume that port "A" is capable of shipping coal into six vessels at once, and that on the average these vessels occupy three days each, it will be seen that an enormous amount of coal will be on hand at, or *en route* to, the port, entailing the provision of very extensive siding accommodation and the use of a very large number of wagons. In this connection, the reader must remember to take into consideration that coal which has been sent forward in the absence of definite orders for shipment which

must be added to that just referred to. Sooner or later, however, the coal is shipped, and the empties are dispatched on their journey back to the colliery, similar stages as a rule being necessary as took place on the outward journey. When shipments are low in relation to the siding accommodation at the port, the business can be carried on fairly satisfactorily if the cost in siding accommodation and wagon usage is ignored. It will readily be appreciated, however, that when the export coal trade is good, there is considerable risk of even extensive siding accommodation at, or *en route* to, the port becoming congested, resulting in traffic having to be held back at the marshalling yards, and thus getting out of course. This results in portions of the different cargoes not reaching the port of shipment in time, and in turn encourages the colliery managers and shippers to dispatch future lots with an even greater margin of time for safety, which also adds to the congestion and causes even greater difficulty.

Let us now compare the conditions under which the cargo of the s.s. *Koalcarrier* would be shipped if a regulation system were in operation at port "A." At the same time as the shipper placed the order with the colliery company it would be necessary for him to advise the dock, and, if they were separate, the railway, authority responsible for the leading arrangements to the dock, of the desire to ship this coal into the s.s. *Koalcarrier* about the date named. The next step would be for the dock representative to ascertain the present position of the vessel in question, and from this, and any other information that was available, check, and, if necessary, adjust, the original estimate of the vessel's arrival time at the port, also taking into account the possibility of securing a loading berth. He would pass on this date to the railway representative responsible for making satisfactory loading arrangements. It is clear that the date selected might prove to be too early, owing to weather and other conditions upsetting his calculations, but he, assisted by the information which the regulations in force require should be given by the representatives of the

ship-owning firms, is in a position to make the best estimate possible, and his interests, in common with those of the colliery, lie in quoting a correct date rather than in erring on the safe side.

The railway representative is now in a position to judge when it will be necessary to lead the traffic. If the system of regulation in force consists, as it sometimes does, of nothing more than a message to the colliery, sent either direct or through some railway representative, to the effect that a given tonnage of coal for a certain ship may now come forward, or may come forward on a specified date, the process of forwarding it is not dissimilar from that described under the non-regulation system, except that the wagons of coal are not lifted from the colliery sidings until the "release," as it is usually called, is given.

It is at least possible, however, that, in the absence of information as to when the release may be expected, the colliery manager has decided he must—in order to be ready when it does arrive—fill the coal into wagons. This has the effect of transferring the waste of wagons and siding accommodation from the port or railway sidings *en route* to the colliery. While this may be in the general interest, in that the congestion it is liable to cause does not adversely affect the traffic from other collieries, it cannot be described as satisfactory. Such a system can only be regarded as efficient in the sense that it may prevent traffic reaching the port before the accommodation there is available for it, and it may in some cases tend to delay loading until nearer the time actually required, but it is liable to cause a good deal of irritation between the railway and colliery representatives, and incidentally make regulation systems unpopular. If, however, the method just described is replaced by a system based on an exchange of information sufficiently in advance to enable each party to appreciate the other's position, the mutual advantages to be derived from a regulation system are considerable.

Let us assume that an arrangement has been made in advance with the management of each colliery or group of

collieries concerned, for a daily conversation (by telephone if necessary) at a fixed time between the railway representative responsible for the leading arrangements and the colliery representative responsible for allocating the output of the colliery to the various purchasers of the coal from day to day. Let us also assume that when this arrangement was made the most convenient time or times for lifting the coal was mutually fixed and train paths arranged accordingly. Say, for example, that the colliery under consideration has a maximum of three engine-loads per day, and that provisional times for lifting have been agreed at 11 a.m., 2 p.m. and 6 p.m., and paths direct from the colliery to the port planned at these times. We are now again in a position to take up the history of the shipment of the coal for the s.s. *Koalcarrier*. We will say that the dock representative has confirmed the 14th as the shipment date, in which case the railway representative will probably wish to lift sufficient coal on the 13th to ensure its being available for an early start the following day, say, 1,250 tons, or two train-loads. He will normally, therefore, mention the matter to the colliery representative in his daily talk about the 10th, by which time there will have been an opportunity of confirming or adjusting the probable arrival date of the ship. Should, however, the colliery representative be concerned about his order for this boat before that date, he will raise the question in any of his earlier daily talks, and the position will be explained to him. The daily talk on the 10th will run on these lines:

Railway representative: "We can lift to-morrow 1,000 tons hand-screened for s.s. ———. 300 tons double nuts for s.s. ———. Suggest trains at 11 a.m. and 6 p.m. Expect to lift 600 tons unscreened, s.s. ———, 12th. 1,250 tons best steam, s.s. *Koalcarrier*, 13th."

Colliery representative: "O.K., to-morrow, except cannot fill for first train until 2 p.m."

Railway representative: "Right."

Colliery representative: "What of the s.s. ———? Advised to us for 1,000 tons double nuts, 14th."

Railway representative: "Our latest news is she sailed from ——— on 8th with cargo. Not expected here before 20th."

Colliery representative: "Right, thanks."

In the talk on the 12th the times the first two trains of coal for the s.s. *Koalcarrier* shall run will be settled, and apart from some exceptional occurrence, all concerned can be satisfied that if the coal is ready for these trains it will be at the port in good time.

It may happen that, owing to the incidence of his other orders, the colliery representative may wish to load and dispatch a portion of the order before it is really required, and where there is *bona-fide* difficulty in waiting until the normal lifting date, some assistance can often be given by lifting a little in advance. On the other hand, for a similar reason operating in the reverse direction, the colliery representative may wish to delay the loading rather longer and the railway representative be able to meet him by running trains later than he would otherwise suggest, at the risk of loss of the margin of time for what, after all, are unlikely contingencies, when a through and prearranged train service is used. The balance of the traffic required to complete the order would be brought forward under similar arrangements on the succeeding days, care being taken to run sufficient trains to ensure that continuous shipping could be maintained. In cases where the parcel of shipment coal from any one colliery is not sufficient to provide a through load for any suitable type of engine that may be available, the advantage which the through working gives is to a small extent lost. The definite knowledge of the number of wagons of coal that will be available for lifting from the various collieries, however, enables the person responsible for making the loading arrangements to combine the working of the various smaller parcels to the best advantage, and plan definite trains to cater for them.

A very simple calculation will indicate the very considerable saving in siding accommodation and wagon usage this method gives as compared with the one previously described. The absence of demand for siding accommodation for loaded traffic, moreover, is liable to react on the time occupied in getting the empty wagons back to the collieries. With the relief on the loaded side, the

possibilities of arranging for a greater proportion of the empty wagons—even though private ones—which require to be sorted for each individual colliery and, to be sent back in direct train loads, or in at least longer stages, to those collieries which have sufficient business to provide a train load or more per day, would be increased. Thus, in the case under notice, the train working with the loaded traffic from the colliery to the port could be balanced by trains of empty wagons between the port and the colliery. With collieries that regularly had fairly heavy shipments, empties would nearly always be available for this purpose, but if their shipments were spasmodic it would sometimes be necessary for the outward trip from the port to take a load of empties for some colliery in the vicinity which was not dispatching loaded traffic to the port that day, and balance things by working in the reverse way on the following one. Similar working could prevail from the collieries in the "Y" area, the only difference being that the additional length of journey would involve a few hours' additional running time.

CHAPTER XII

POOLING OF PRIVATE WAGONS

WE can develop the illustration discussed in the previous chapter to demonstrate the effect of the pooling of privately-owned mineral wagons. We have already seen that, assuming a reasonably extensive shipment is taking place from any colliery, it will, as a rule, be possible for train loads of that colliery's wagons to be accumulated for direct working back to the colliery. It will, however, be obvious that this can only apply so long as a fairly heavy shipment from the individual collieries under consideration is maintained, and that in times when shipments are quiet, and always in regard to collieries which only ship in comparatively small parcels, there will not be sufficient empty wagons available within a reasonable time to complete a train load for direct working, and that these will, therefore, require to be staged through the marshalling yards between the port and the colliery along with other similar wagons whose "home" is in the same direction.

To the extent that the pooling of wagons belonging to a number of collieries enables a train load of the pooled wagons to be available at a shipment point earlier in those cases where through-working is already possible, and available in those cases where through-working without pooling is not possible, two of the advantages of pooling are obtained; but the general effect is much more far-reaching than this.

The shipment of coal is a wholesale business which affords opportunities that the more retail industrial, and

TABLE SHOWING AVERAGE DAILY DESTINATION OF WAGONS FROM COLLIERIES 1, 2 AND 3.

From	To.									Total.
	Shipment.	Industrial and Landsale.								
	Port "A"	BC.	HP.	LP.	PN.	KJ.	JG.	DG.	GN.	
Colliery 1	50	10	15	10	—	—	—	12	3	100
,, 2	30	—	5	20	10	5	15	10	5	100
,, 3	25	—	30	25	13	—	—	5	2	100

particularly the household, trade cannot possibly do. The usage obtained from wagons in the latter type of trade is consequently distinctly worse than that obtained from the former, and this in spite of the delays due to bad weather which are inseparable from shipment work. The opportunities for saving in wagon usage as the result of "pooling" are, therefore, greater with the wagons in the landsale trade.

The case for "pooling" from the wagon owners' point of view is that the earlier accumulation of sufficient wagons for a "home" destination affords an opportunity for a greater degree of direct working which reduces the empty journey time, together with the fact that to the extent the effect of shortages at one colliery are cancelled out by the surplus at others, a less total margin of wagon stock is necessary. The railway company saves a certain amount of sorting and gains the advantages which through working gives.

To take a very simple illustration, we will consider the effect of pooling the wagons belonging to collieries numbered 1, 2 and 3 in area "X" on Diagram 15, page 120. The output of each colliery is approximately 100 wagons per day. On the average, Colliery 1 sends 50 wagons for shipment to "A" and the balance for industrial and landsale purposes divided over the area, as indicated in the table on page 130, which also gives particulars of the average daily distribution from each colliery. The average discharges at destination should approximately coincide with the average forwardings, and it will be seen from the table, therefore, that, apart from the shipment traffic from Colliery 1 to "A," there is no case in which wagons belonging to either of the collieries are unloaded per day at any point or on any branch in sufficient numbers to warrant the running of a through train to the colliery. Without pooling, therefore, the remaining wagons must be staged through successive marshalling yards along with other wagons travelling in a similar direction. If, however, the wagons belonging to these collieries are

pooled and regarded as in common use, it will be obvious from an examination of the table that considerable opportunity for reduction in journey time will be created. For example, there are approximately two train loads per day from "A," and two from "P," the latter being composed of empties arriving from the directions of "L" and "H." Instead, therefore, of its taking an average of twenty-four hours to accumulate a load from "A," a load will be available on the average each twelve hours, and similarly from "P," and while the staging of all the wagons used for shipment can be entirely avoided, that for those passing through "P" can be considerably modified.

The point is of sufficient importance to justify further development, and an attempt has, therefore, been made to present alternative estimates of the time occupied in the return of the whole of the empty wagons under individual and pooled ownership respectively in the statements given on pages 133 and 134. It should be emphasised that the figures given must, to a large extent, be based on arbitrary estimates because of the impossibility of doing otherwise when presenting an imaginary case. At the same time, very great care has been taken to see that the conditions taken are reasonably comparable with what might occur in good railway practice and that the two sets of figures are not unfairly comparable. Many practical railwaymen would doubtless regard the estimated times in the statement referring to the individual ownership as ideal rather than probable, and the writer would not seriously quarrel with this. It should, however, be pointed out that the effect of this is simply to weight the case against "pooling." Even with this weight, however, it will be noticed that pooling reduces the return journey time by rather more than one-third. The reader who follows the tables through in conjunction with Diagram 15 will notice that the wagon journeys are planned on the basis that it is not necessary to enter every marshalling yard *en route* up to the stage that there is a sufficient accumulation to allow of through working to one colliery, but that a selection considered to

TABLES SHOWING APPROXIMATE TIME FROM WAGONS BEING EMPTIED TO ARRIVAL BACK AT COLLIERY
A.—UNDER INDIVIDUAL USE.

Unloading Point.	Wagon Owner.	Time Occupied After Wagons Emptied. To accumulate load.	Waiting forward service.	In marshalling yard. Name of yard.	In marshalling yard. Time.	Running time on journey.	Total.	No. of wagons.	Wagon hours.
	Colliery.	Hours.	Hours.		Hours.	Hours.	Hours.		
Port "A" ..	1	24	—	—	—	6	30	50	1,500
" "	2	6	—	G	12				
				N	12	6	36	30	1,080
" "	3	6	—	G	12				
				N	12	6	36	25	900
Line B–C ...	1	—	6	C	12				
				G	12				
				N	12	6	48	10	480
" H–P... .	1	—	6	P	12				
				N	12	4	34	15	510
" "	2	—	6	P	12				
				N	12	4	34	5	170
" "	3	—	6	P	12				
				N	12	4	34	30	1,020
" L–P ...	1	—	12	P	12				
				N	12	4	40	10	400
" "	2	—	12	P	12				
				N	12	4	40	20	800
" "	3	—	12	P	12				
				N	12	4	40	25	1,000
" P–N ...	2	—	6	N	12	2	20	10	200
" "	3	—	6	N	12	2	20	13	260
" K–J	2	—	6	J	12				
				G	12				
				N	12	4	46	5	230
" J–G... .	2	—	6	G	12				
				N	12	3	33	15	495
" D–G.. ..	1	—	12	G	12				
				N	12	3	39	12	468
" "	2	—	12	G	12				
				N	12	3	39	10	390
" "	3	—	12	G	12				
				N	12	3	39	5	195
" G–N .	1	—	6	N	12	2	20	3	60
" "	2	—	6	N	12	2	20	5	100
" "	3	—	6	N	12	2	20	2	40
Average 34·32 wagon hours.								300	10,298

B.—UNDER POOLING SCHEME.

Unloading point.	Time Occupied After Wagons Emptied.						No. of wagons.	Wagon hours.
	To accumulate load.	Waiting forward service.	In marshalling yard.		Running time on journey.	Total.		
			Name of yard.	Time.				
	Hours.	Hours.		Hours.	Hours.	Hours.		
Port "A"	12	—	—	—	6	18	105	1,890
Line BC ...	—	6	C	12				
			G	12	—	30	10	300
,, JG .	—	6	G	12	—	18	15	270
,, DG	—	12	G	12	—	24	27	648
,, KJ . ..	—	6	J	12				
			G	12	—	30	5	150
					3	3	57	171
,, HP	—	6	P	12	—	18	50	900
,, LP	—	12	P	12		24	55	1,320
					4	4	105	420
,, PN	—	6	N	12	2	20	23	460
,, GN .	—	6	N	12	2	20	10	200
Average 22.43 wagon hours							300	6,729

be probable has been made, and that, where it is considered that conditions would make it necessary to enter a yard, an average of twelve hours has been allowed for sorting, accumulating a load for the next point, and leaving the yard.

As previously stated the comparison between the results shows a reduction in empty wagon journey time of rather over one-third in favour of the pooling scheme. There are few, if any, actual schemes in operation where the gain has not been considerably greater than this. The difference is due to the reasons already advanced, and perhaps even more to the simplicity of the conditions of the scheme set out as compared with those of an actual scheme. In the case taken for our example the "home" marshalling yard is common to all three collieries. In many actual cases each colliery would have a different "home" marshalling yard, and in some cases, at least, there would not even be a direct service between all of them. Say, for example, one colliery in the same pooling group had been between "JF" and another between "EC," an odd wagon belonging to the first colliery emptied at a station between "DE" would have to wait a service to "E" (say six hours) and spend, say, twelve hours at "E" waiting a service to "G," another at "G" waiting a service to "F," and, say, another before going from "F" to the colliery, a total of 42 hours. Under a pooling scheme it would go to "E" (say six hours) and direct to the second colliery (twelve hours), a total of eighteen hours. As before, these times are arbitrary averages, and are probably understated. The greater number of wagons and variety of destinations which are normally involved, moreover, all tend to increase the possibilities and multiply the advantages of a pooling scheme. The example taken has probably, however, been more than sufficient to illustrate the direction in which a comparatively small pooling scheme works to advantage, and to indicate the possibilities of pooling on a much larger scale, to the mutual advantage of the colliery wagon owner and the railway company.

CHAPTER XIII

FREIGHT TRAIN CONTROL

THE principles underlying the establishment and working of freight train controls were discussed at some length in *British Railway Operation*. Much, moreover, has been written in the way of description and illustration of systems which use in one form or another either the time or geographical type of control board referred to in the chapter dealing with that subject. It is, therefore, proposed to devote the space that can be allotted to this portion of our subject to a more detailed description of the further development of the use of a diagram in lieu of a control board.

It is fairly generally admitted that whatever the advantages may be of the systems which make use of either type of control board, they possess the common disadvantage that they do not leave behind a permanent record of what has happened. It is true that they are, in this respect, no worse than the systems they superseded, but, as increasing pressure upon the capacity of British lines has made it essential that the workings shall be planned with almost scientific exactness, the need has become more apparent for a definite record of what has happened, on which to base future arrangements. Nor is the value of such record confined to its use in connection with train workings. As we have seen, a fairly exact knowledge of line occupation is necessary for many other purposes.

The compilation of data similar to those which appear on the guard's journal—especially if compiled in such a way

that the successive days' workings of a particular train are readily comparable—which is now kept in many controls using control boards, is a small step in the right direction. It has the disadvantage that the work of compiling it is "extra" to the work necessary for controlling purposes, and theoretically, at any rate, may make it necessary to reduce the area controlled by an individual, though in practice cases are rare where it is possible to plan the division of work so exactly as this. Its greatest weakness, however, is that it does not show the running of one train in relation to the others which it may have affected or been affected by, yet this is essential if maximum efficiency is to be obtained. If the reader can imagine an attempt being made to discuss the sort of question referred to in Chapter II—with the data in regard to each train set out in writing on a separate card or sheet, instead of being presented in the form given on Diagram 4—he will appreciate the need for some development which will avoid the latter weakness. As will be seen later, the diagram system avoids both the disadvantages mentioned, the movements which take place in substitution of those necessary when using a control board automatically providing the desired permanent record.

The type of diagram used as a substitute for the control board is very similar to that used in Diagram 4. A specimen diagram for the lines "BCF," "CE" (Diagram 1) is reproduced, Diagram 16, with the working for the first two hours filled in. It will be noticed that the last train in either direction is incomplete pending receipt of reports which will not come to hand until after 8 a.m. On the left hand side are the names of the principal stations and other points at which trains may be stopped, either for working purposes or because the section ahead is occupied. At the head and foot of each form, and intermediately if the number of trains starting or finishing at an intermediate point is such as to make this desirable, space is provided in which the necessary description of the train and its load, etc., may be entered. The horizontal lines, other than those representing a possible stopping place, which were included in

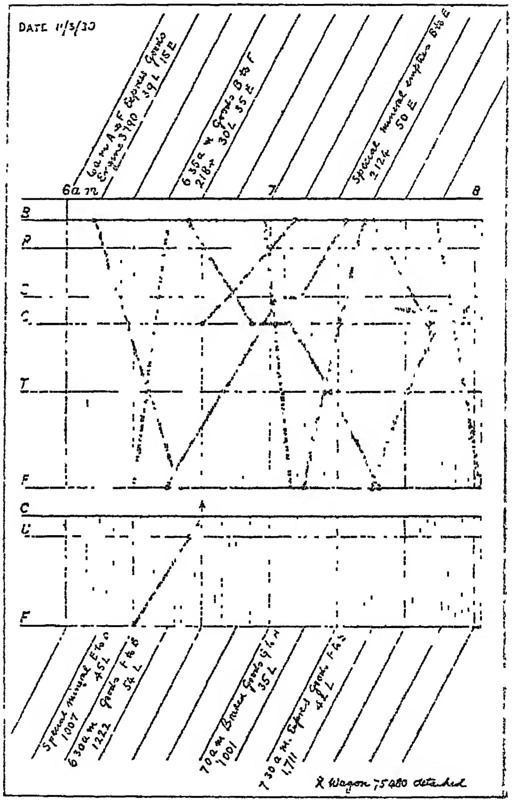

Diagram 16.

Diagram 4, because this was worked out on squared paper, are omitted. As a rule, it is convenient for the form to represent twenty-four hours—unless the line is opened for some time less than the natural day—simple carriers being provided in which the parts of the form currently out of use can be held, without making the forms unwieldy for the controller to handle. Unless the detailed running of passenger trains is reported for controlling purposes, it is an advantage to have these printed on the form in advance, indicated by lines of some distinguishing colour or kind.

The exact arrangement of the different sections of the line is a matter which requires careful thought. If, for example, when planning the diagram for the lines "BCF" and "CE" respectively, a greater number of trains from "B" had continued to "E" rather than to "F," it would have been an advantage to arrange the first section to read "BCE," the "CF" section coming below. It is important so to plan the diagram and arrangements for using it that a train shall not be shown as travelling over the portion of the diagram representing a line over which it does not actually pass, but, as far as possible, the trains should be shown continuously without a break. In most cases, the use of a distinguishing colour is sufficient to indicate the respective use of duplicate lines, but, where more than two lines are available, or where the traffic over two lines is exceptionally heavy, it is advantageous to duplicate such sections of the diagram, the trains being shown on the line over which they actually run.

On lines where the density of trains is such as to allow of it without impairing the ease of reading, it is advantageous to have both Up and Down trains on one diagram. The effect of junction working is thus more readily seen. Where the density is considerable, however, it is better to have separate diagrams for Up and Down directions respectively. The use of different colours for the various types of trains, and especially a distinguishing colour to show the delays, is desirable in lieu of the different type of line which is used in Diagrams 4 and 16 for convenience in printing.

The controller starts the day with a blank form. As a train is reported, he fills in the necessary details on the line provided for the purpose, and, as the train proceeds, and he receives his further reports as to its progress, he marks the points on his diagram, and connects them with a line of appropriate colour. Notes of exceptional occurrences are entered at, or referred to, the appropriate point on the diagram, standard abbreviations being used for the more common type of occurrence, e.g., S.E., Stop and Examine signal; P.W., Permanent Way stop; and so on. The controller thus has before him a record of what has happened, and as, in the absence of reports, he may assume that the trains have been continuing on their normal course since the last report was received, a fairly exact picture of the position of affairs is available at any moment. Provision could, if necessary, be made on the form for reports to be shown of traffic waiting to be lifted, as is sometimes done on control boards, but it is generally found to be more convenient to keep these records on a separate form.

At the end of the day a detailed record of the working of every train, in a form that can readily be appreciated, is thus available, and, what is even more important, its relation to the other trains which have run is apparent. This record, the value of which is discussed in detail below, has been provided, incidentally, without any additional reports or records being made than are essential for control purposes.

The diagram is at least as useful to the controller for his immediate purpose as either of the control boards which it replaces, but it has the further advantage from the controller's point of view that it enables him to see very readily the opportunities he has missed, and the adjustments that he can make with advantage on future days to those portions of the working which are left to him to improvise. The greatest advantage, however, lies in the fact that a control provides in this way the data on which the whole of the working in the area concerned can be supervised, and, if necessary, reorganised to obtain the maximum efficiency.

Data are provided, regularly, promptly, and without additional cost, which it would otherwise be impossible to provide promptly, and impracticable to provide regularly because of the time and cost involved. Individual delays can be seen, the cause of them being apparent from the diagram. If they are such that action is necessary to prevent their becoming chronic, the sort of remedy necessary and the extent to which it is possible to apply it, is indicated. Groups of delays are similarly apparent, and an indication of the immediate or general cause given. The possibilities in the way of spreading out the trains more evenly and so limiting the reaction of delay to one train upon following ones can also be seen. The need for fewer, or alternatively more, block posts is indicated, while the general adequacy or otherwise of the accommodation is demonstrated.

The value of the bird's-eye view which the completed diagram gives of the actual working from day to day, is almost incalculable to those charged with the responsibility for planning the layout, staffing, and organisation. The whole perspective is altered. In place of the examination of the laboriously compiled statistical records, which at the best afford but an indication of a possible case for further inquiry, the diagram gives a correct picture of what is wrong, and to a very large extent indicates not only what has caused the difficulty, but the correct remedy to apply. Nor does its usefulness stop there. We have previously emphasised the need for the application of constructive thought to modern railway working, as distinct from the very necessary work of maintaining a high standard in connection with whatever conditions are already in operation. The study of the diagram not only suggests lines of inquiry which may be worth pursuing, but it provides the data for examination in such a form as enables the user to be reasonably certain of the soundness of any conclusion arrived at, instead of having to make decisions on generalised expressions of opinion, based on more or less accurate observation of a series of disconnected incidents.

CHAPTER XIV

STATISTICS

PERHAPS the simplest way to illustrate the limitations of the statistics generally, though somewhat loosely grouped under the term "ton-mile statistics," to which attention was drawn in *British Railway Operation,* will be to consider their application to the freight trains running over a portion of the area shown on Diagram 1. The wagon-miles per engine-hour figure, which has been said to be the final test of efficiency of freight train working, but which can more correctly be described as an indication of the work done by the freight locomotives in steam, will be a convenient one to use for this purpose.

It is generally agreed that the conditions as to the nature and density of traffic, line equipment, gradients, and many other features which affect such a figure, vary so widely between different systems, and indeed different parts of the same system, that comparisons between them are of little value. It is usually accepted, therefore, that the results for the same line or area should be compared for corresponding periods.

To keep the illustration within reasonable limits of size, we will assume that the lines which converge at "C" on Diagram 1, namely, "CB," "CF," and "CE," and "CD," are worked as a self-contained area, and that for two comparative periods the wagon-miles per engine hour for this area are:

	Wagon miles	Engine hours	Wagon miles per eng hour
March, 1929	2,083,364	17,508	118.9
March, 1930	2,028,527	17,016	119.2

It will be noticed that with a small reduction in the total wagon-miles for the area in question, which in itself is, of course, a factor which is liable to affect the result as expressed in wagon-miles per engine-hour, there has been a variation sufficient to indicate to one who is prepared to regard such a figure as a reliable guide, that the working results are rather better in the second period than in the first one, the comparative figures being 118.9 and 119.2 wagon-miles per engine-hour respectively.

As previously explained, this figure refers to an area composed of four different lines, and it is desirable to examine this conclusion in the light of the figures for the four separate lines. Before quoting these, mention should be made of the fact that it has been assumed the working over these lines did not in any way overlap. In practice, there would be considerable overlapping, which intensifies the weaknesses of such figures as tests of the efficiency of working.

March	Line	Wagon miles.	Engine hours	Wagon-miles per eng.-hour.
1929	CB	280,016	2,154	130
1930		265,987	2,128	125
1929	CF	918,400	6,122	150
1930		1,060,040	7,338	144
1929	CE	587,950	6,532	90
1930		435,201	5,120	85
1929	CD	296,998	2,700	110
1930		267,299	2,430	110

It will be seen from the above statement that the comparative figures of wagon-miles per engine-hour for each one of the four separate lines reverses the impression created by the total figure, those for the second period being lower than those for the first in all cases but one, in which they are equal. Further consideration of the other columns of the statement will bring to light the fact that the reverse impression created by the total figures is due chiefly to variations in the amount of traffic passing over the respective lines. It is clear, for example, that the conditions on the line "CF" allow of a higher average of wagon-miles per engine-hour being obtained, while those

on the line "CE" operate in the reverse direction. This may be due to a number of causes. It may, for example, be due to the nature of the country through which the line passes necessitating heavy gradients and difficult curves or other natural impediments to a big load or high speed, or it may be due to the nature or density of the traffic. Heavy traffics as a whole reduce the possibilities, and light ones increase them, so long as the wagon-unit, as distinct from the ton-unit, is used, while it is obvious that more time is likely to be taken to travel over a line where the occupation is high than otherwise. It may further be affected by the equipment of the line; the signalling arrangements may be better, faster, or more powerful engines may be available, or the independents and refuge lines on one line may impose more limitations on the possible length of the train than on the other. In passing, it should be noted that the variation in the figures on all the other lines react upon the figure for the whole area.

Before we reverse our previous view, and conclude that the working on each of these three lines is proved by the figures quoted to be distinctly less efficient in the second than it was in the first period, we had better examine the case in more detail still, and for this purpose we will analyse the figures for the line "CF," which, taken as a whole, show the largest reduction. In the next statement, therefore, particulars are given of the wagon-miles, engine-hours, and the resultant wagon-miles per engine-hour earned by each train which ran over line "CF" during the two periods, the figures being so arranged that the working of each train can be compared with the corresponding train in the other period.

Statement showing Wagon-Miles per Engine-Hour for each Train on Line CF for Month of March, 1929 (Roman type), 1930 (Italic type).

No. of train.	Wagon Miles	Engine-Hours.	Wagon-Miles per Engine-Hour.	Increase (Italic) or decrease (Roman).
1	28,700	191	150	
	28,880	*190*	*152*	*2*

No. of train.	Wagon-Miles	Engine-Hours.	Wagon-Miles per Engine-Hour	Increase (Italic) or decrease (Roman).
2	31 500	230	137	
	33,200	*222*	*140*	*3*
3	25,900	141	183	
	23,160	*126*	*184*	*1*
4	24,500	143	170	
	24,800	*142*	*174*	*4*
5	—	—	—	—
	28,000	*213*	*131*	—
6	35,000	228	147	
	34 660	*230*	*151*	*4*
7	27,300	130	210	
	27 800	*129*	*215*	*5*
8	28,000	223	126	
	27,000	*210*	*129*	*3*
9	28,000	205	137	
	29,000	*209*	*139*	*2*
10	29,400	200	147	
	29,100	*195*	*151*	*4*
11	27,300	136	201	
	27,200	*132*	*206*	*5*
12	—	—	—	—
	16,000	*266*	*60*	—
13	24,500	250	98	
	24,000	*238*	*101*	*3*
14	35,000	239	146	
	36,000	*240*	*150*	*4*
15	28,000	175	160	
	27,600	*167*	*165*	*5*
16	28,000	186	151	
	27,800	*184*	*151*	—
17	—	—	—	—
	30,400	*247*	*123*	—
18	31,500	232	136	
	31,400	*227*	*138*	*2*
19	35,000	189	185	2
	33,740	*184*	*183*	
20	30,800	189	163	
	32,000	*190*	*168*	*5*
21	18,200	153	119	
	20,000	*160*	*120*	*1*
22	—	—	—	—
	28,000	*207*	*135*	—
23	28,000	153	183	
	29,000	*157*	*185*	*2*

No. of train	Wagon-Miles	Engine-Hours.	Wagon-Miles per Engine-Hour.	Increase (Italic) or decrease (Roman).
24	29,400	224	131	
	29,000	*216*	*134*	*3*
25	27,300	161	169	
	28,000	*164*	*171*	*2*
26	—	—	—	—
	20,000	*196*	*102*	—
27	24,500	129	190	
	24,000	*119*	*201*	*11*
28	35,000	269	130	
	36,000	*272*	*133*	*3*
29	28,000	186	151	
	28,500	*184*	*155*	*4*
30	28,700	198	145	
	28,800	*196*	*147*	*2*
31	31,500	233	135	
	32,000	*231*	*138*	*3*
32	—	—	—	—
	17,000	*200*	*85*	—
33	25,900	152	170	
	26,000	*147*	*177*	*7*
34	24,500	277	88	
	25,500	*275*	*93*	*5*
35	35,000	218	161	
	34,500	*241*	*161*	—
36	27,300	149	183	
	26,000	*136*	*191*	*8*
37	28,000	156	179	
	27,700	*150*	*184*	*5*
38	28,700	167	172	
	30 000	*173*	*173*	*1*

The result of the examination appears to reverse again the impression created by the figures last examined. With one exception, each individual train is shown to have obtained at least as good a result expressed in wagon-miles per engine-hour as in the earlier period, and in most cases a better one. What has actually happened is that a variation in the traffic offered for conveyance—the principal influence in this case being an increase in traffic—has made it necessary to run additional trains, which, owing to the

nature of the new traffic, cannot give figures of wagon-miles per engine-hour which are up to or beyond the average of the trains which the traffic in the previous period necessitated. This may be due to the nature of the traffic or its relative urgency, or to the quantities in which it is offered for conveyance, or other circumstances beyond the control of the person in charge of the working. Its effect on the total figures for the line under consideration is sufficient to make it appear that the general standard of efficiency has been lowered, though, in fact, the figures for the individual trains that have run in both periods appear to indicate the opposite result. In one case only, train No. 19, a worse result is indicated, the comparative figures being 185 and 183 wagon-miles per engine-hour respectively. Let us, therefore, consider an analysis of the working of this train, which is now given.

Statement showing Wagon-Miles per Engine-Hour for each day for Train No. 19, during the month of March, 1929 (Roman type); 1930 (Italic type).

Date.	Wagon-Miles.	Engine-Hours.	Wagon-Miles per Engine-Hour.	Increase (Italic) or decrease (Roman).
1	1,675	8·0	199	
	1,610	*8·0*	*201*	*2*
2	1,505	8·0	188	—
	Sunday.	—	—	—
3	Sunday.	—	—	—
	980	*7·6*	*129*	—
4	910	7·6	120	
	1,400	*7·0*	*200*	*80*
5	1,330	7·4	180	
	1,335	*7·4*	*180*	—
6	1,400	7·8	180	
	1,295	*7·2*	*180*	—
7	1,430	7·3	196	
	1,505	*7·5*	*201*	*5*
8	1,365	7·4	184	4
	1,295	*7·2*	*180*	
9	1,400	7·1	197	—
	Sunday.	—	—	—
10	Sunday.	—	—	—
	1,050	*7·9*	*133*	—

Date.	Wagon-Miles.	Engine-Hours.	Wagon-Miles per Engine-Hour.	Increase (Italic) or decrease (Roman).
11	980	7·2	136	
	1,440	*6·9*	*209*	*73*
12	1,435	7·2	199	2
	1,400	*7·1*	*197*	
13	1,480	7·4	200	
	1,470	*7·2*	*204*	*4*
14	1,470	7·6	193	6
	1,400	*7·5*	*187*	
15	1,505	7·5	201	
	1,365	*6·7*	*204*	*3*
16	1,400	7·3	192	
	Sunday.	—	—	—
17	**Sunday.**	—	—	—
	1,050	*8·0*	*131*	—
18	1,085	7·6	143	
	1,295	*6·3*	*205*	*62*
19	1,310	6·5	202	
	1,330	*6·6*	*202*	—
20	1,415	6·9	205	
	1,385	*6·7*	*207*	*2*
21	1,400	7·4	190	
	1,260	*6·6*	*191*	*1*
22	1,465	6·9	212	3
	1,400	*6·7*	*209*	
23	1,260	7·0	180	
	Sunday.	—	—	—
24	**Sunday.**	—	—	—
	875	*7·1*	*123*	—
25	945	7·1	133	
	1,400	*6·8*	*206*	*73*
26	1,330	7·3	182	1
	1,210	*6·7*	*181*	
27	1,435	7·0	205	
	1,350	*6·6*	*205*	—
28	1,165	5·7	204	7
	1,260	*6·4*	*197*	
29	1,435	7·4	194	4
	1,295	*6·8*	*190*	
30	1,470	7·0	210	—
	Sunday.	—	—	—
31	**Sunday.**	—	—	—
	1,085	*7·5*	*145*	—

To obtain the explanation of the apparent reduction in efficiency as measured by this figure, it is necessary to consider the comparative results for each individual day. On looking at these, we find that an absolute comparison is rendered difficult by the effect of the calendar upon the working days, but, if we compare the dates on which the train ran in both periods, we find that in ten cases there was an increase in the wagon-miles per engine-hour, and in seven cases a decrease, the latter being on the whole considerably smaller than the former. This being so, it is not unnatural to have expected that the whole month's figures would have indicated a similar improvement. The many changes in the position from day to day tend to make it a little difficult to isolate any particular cause for the reduction. On some days it would appear that the traffic to represent a maximum load for the engine in use was not available. On others, it may be that a less powerful type of engine was available than formerly, which necessitated a reduction of the load, or a slower speed which was reflected in the engine-hours. On certain days increases of other traffic may have added to the delay *en route*, and a number of other similar considerations which do not vary with any degree of regularity or consistency over a period have acted upon the length of time taken to complete the journey, and, in turn, reacted upon the final result. We can, however, locate one reason why a lower figure results from a summary of the month's working. It will be noticed that the load conveyed on the first day of the week is invariably lighter than that on the other days. This may be due to various causes. For example, there may be specially urgent traffic of one sort and another which necessitates a lighter load on Monday, for the purpose of obtaining a higher speed, and that the increase in speed is not sufficient to counteract the reduction in load that this necessitates. Or it may be that the traffic which arises on Mondays is lighter than that for the other days of the week, but there is still sufficient to make it necessary to run the train for the purpose of giving a satisfactory service. As it happens, there were five Mon-

days in the month of March in 1930, as compared with four in the previous year, and the effect of this on the figure is to present a worse figure for the month as a whole. If all Mondays' working is excluded, the indication presented by the total figures is again reversed.

After this careful analysis of a case in which a large proportion of the possible complications have been excluded because of its simplicity, the reader must be left in some doubt whether, indeed, the working in the area in question was better or worse in either period. Moreover, sufficient has probably been said to indicate that the variations which are liable to affect the figures are not of the kind which—over a reasonably long period—can be regarded as cancelling each other out.

Other things being equal, an improvement in the wagon-miles per engine-hour is a very desirable feature to aim at, and the publication of the results expressed in these terms may act as a stimulus in this direction; but it would appear that the figure can be of little value as affording any real indication of the success obtained, or as a test of the efficiency of the working. Regular statistical information which will convey a correct picture of the results obtained is essential. Ton-mile statistics undoubtedly represented a considerable advance upon any statistical information which had previously been compiled. The limitations of such statistics, however, appear to be such that further improvements must be evolved and applied before they can be regarded as adequate.

CHAPTER XV

CONCLUSION—ORGANISATION AND EDUCATION

IN conclusion, it may be well briefly to review the ground that has been covered, and to discuss the relations between the problems which have been dealt with. Following the introduction, in which the nature of operating problems and the scope that still remains for improvement in British operating methods was emphasised, attention was drawn to the need for a careful selection of an appropriate method of approach to whatever problem is under consideration, and an indication given of certain lines which had proved to be of value. Practical problems affecting line occupation were then examined, the general order used in *British Railway Operation* being adhered to, so that the illustrations to the principles enunciated therein might more readily be followed. These demonstrated that the variation in the speed of trains and the order in which trains of varying speeds followed each other, affected the line capacity and the expense—both in equipment and man power—of signalling, thus indicating that problems of engine design, signalling, train working, and accommodation are interdependent. Consideration was then given to the working at different types of terminals, which illustrated that the terminal working both at stations and marshalling yards must, if the highest operating standards are to be secured and maintained, be related to the group of questions just mentioned. The discussion of the various questions dealing with train working, which followed, all emphasised the same tendency, extending the question by showing that

questions of public convenience, and of the costs of different forms which train working necessitates, are inter-dependent to an extent that makes it desirable they shall be considered together, and drawing attention to the possibilities which are presented by co-operation with the trader, to mutual advantage. The difficulty of providing figures to indicate the cost or comparative efficiency of the different sections of railway operation illustrated by the article on statistics all tended to emphasise the inter-dependence referred to. No reference has been made to the questions normally regarded as included in the term "organisation," nor indeed to those aspects of it which refer particularly to the immediate section of railway work we have been considering. At the same time it will be obvious that all the matters discussed have a direct bearing on these questions. The inter-dependence of each and every aspect of traffic working upon all the rest, and the action and reaction of all these upon the cost and quality of the service provided, to which attention has been attracted, all seem to point to the undesirability of any greater division of responsibility than is absolutely necessary.

Whatever advantages are obtained from the degree of specialisation which present divisions may give must have set against them the definite disadvantages of the risk of unbalanced or inharmonious functioning of the separate portions, and the certainty of slower functioning of the concern as a whole, together with the increased cost of a less simple organisation. The omission of any attempt to illustrate the advantages or disadvantages of any particular system of organisation at present in operation, when compared with any other, is not due to the lack of opportunity in this direction, but rather to the fact that the question is not one on which a sound decision can be reached by the consideration of even a large number of typical cases out of the very many that can be produced. Except on very broad lines, it would appear to be impossible to demonstrate that any one form of organisation is better than another. The value of a comparison of practical examples

is vitiated by the relative efficiency or strength of character of the personnel in charge at the moment of consideration, and by the varying degrees in which, under the many different forms in use, that of departmentalism on the one hand, and of centralisation or decentralisation on the other, vary. Some authorities appear to hold the view that the form of organisation is not, within reason, very important, so long as capable persons are selected to fill the principal positions. Most agree that it is better to have a bad organisation and a good personnel than the reverse. Both these views appear to give some support in favour of the adoption of the organisation that is simplest and least expensive. Compared with the organisation of many of the large concerns which have resulted from the increased application of the principle of rationalisation to British industries, the typical British railway organisation does not compare unfavourably from the point of view of simplicity. It may well be that the economic conditions at present prevailing will lead to a still further simplification, and that although this may be done primarily with a view to reducing expense, experience may show that the view held by the great majority of the rank and file of the railway staff, that it would also lead to greater efficiency, is the correct one.

It is hoped also that sufficient has been said to indicate the possibilities that still remain for the application of scientific principles to railway operation. It may be true that many of the numerous factors which enter into the question, to which attention has from time to time been directed, are never sufficiently stable to enable railway operation to become an exact science. We are, however, a long way from reaching the point where there is any danger of this aspect of the matter arising as a practical problem. Notwithstanding the advance made in the last quarter of the first century of British railways, there would still appear to be many who regard the term "scientific"—as applied to railway questions—as synonymous with "unpractical," and the term "experience" as applicable to the number of

years which a particular post has been filled, as distinct from the amount of thought given to the problems of that post. Such an outlook is not, of course, confined to railways. It is common amongst the under-educated—using the term in its true sense—of all occupations.

The remedy both for the outlook and the result of the outlook is education, and a very brief summary of the railway position in this respect may not be out of place. Classes for the purpose of instruction in such matters as the rules and regulations, how to keep accounts, duties of ticket collectors, and so on, have been held either spasmodically as the shortage of men for a particular grade necessitated, or for continuous periods with a view to widening the general opportunities for promotion, for many years. In some cases they have been the result of voluntary effort on the part of the staff themselves. In others they have been more or less definitely organised and supported by the railway company, and there have been many variations between these two in differing degrees. These classes, for the most part, however, have been confined to the directly vocational aspect of the subject dealt with, and are therefore hardly within the term "educational" in the sense in which it is used here.

The urge for something with a real educational value led to the founding of railway debating societies—notably on the Great Western system at Paddington and the North Eastern system at York—which are now established at many large centres. Some twenty years ago, the first comprehensive scheme of railway education was launched by the North Eastern Railway in conjunction with the Universities of Durham and Leeds. The primary object of this scheme, which is limited to the clerical grades, was to develop and increase the mental capacity of those sharing in it, the mental exercises which the lectures and independent study and reading afforded being applied to railway questions so that the student should not only develop the power and habit of thought, but should develop it in relation to questions concerning his business,

and incidentally gain a wider knowledge of the methods of conducting those branches of the business with which his usual work did not bring him in contact. Perhaps the best evidence of the satisfactory results of this scheme is that it was extended to cover the whole of the area which the greater London and North Eastern Railway covers, shortly after the amalgamations due to the Railways Act of 1921.

More recently the Institute of Transport has encouraged study on much the same lines—the syllabuses for the two schemes being almost identical—by its examination scheme and as a result of the courses of lectures which have been commenced in various parts of the country under this scheme, similar opportunities are available to the staffs of other railways. Here again, however, the standard required before qualifying for the more technical side of the Institute's examinations is such that they are in practice confined to the members of the clerical staffs. No one who has been in touch with members of the staff who have taken advantage of the opportunities thus offered can have any doubt that these schemes have fulfilled the object set out above, with the result that there is an increasing proportion of the railway staff who are fitted to approach railway problems on a more scientific basis.

A scheme of education which stops at this point, however, can hardly be regarded as complete, and it is a little disappointing—though the difficulties of the period are appreciated—that it should not before now have taken the course which would appear to have been the natural one, and have provided opportunities for organised research by those it has trained for the purpose, with a view to demonstrating the soundness or otherwise of present methods of railway working and discovering improved ones. Another disappointing feature is the absence of any scheme which provides opportunity in this direction for other than clerical grades. There is amongst the other grades a considerable number—though possibly not a high proportion—who because of either natural ability or personal effort, are

educated in the soundest sense of the word, and who, with suitable guidance, could make a valuable contribution towards the efficiency of the industry which provides their livelihood, which it cannot afford to neglect. There is a large number of others who, with suitable assistance, might soon reach this standard. There are signs from more than one quarter of increased interest in these important aspects of educational work.

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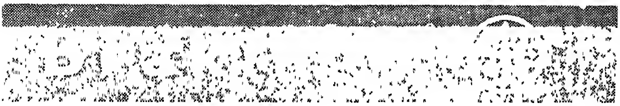

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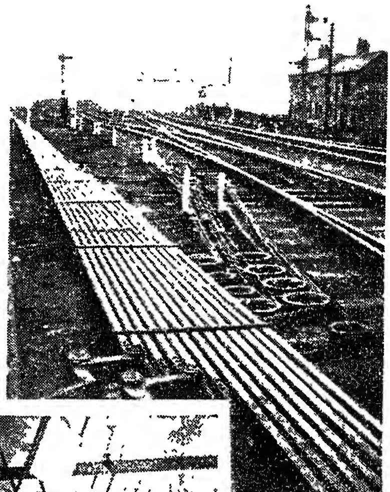

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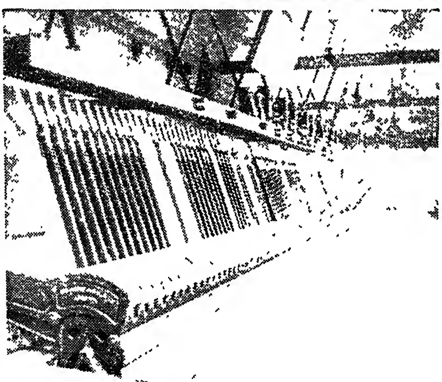

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